TABLE A.2-7

1977 STATEWIDE MONTHLY DISTRIBUTION OF FORMULATION 10 NONSYNTHETIC HYDROCARBON PESTICIDE EMISSIONS IN CALIFORNIA

EMISSION FROM FORMULATION 10 PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
AGRICULTURAL														
HERBICIDES														
AGENCIES, OTHER	(000200)													
-O- AROMATIC PETROLEUM SOLVENTS	00752	0	0	2	13	3	43	0	31	39	1	0	0	132
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM HYDROCARBONS	00473	1	13	29	31	8	32	11	71	28	0	0	0	223
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
ALFALFA	(000300)													
-A- AROMATIC PETROLEUM SOLVENTS	00752	273	230	0	0	0	0	0	0	0	0	0	0	504
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM HYDROCARBONS	00473	1777	4238	2897	1200	368	125	29	64	12	0	0	0	10711
		0	0	0	0	0	0	0	0	0	0	0	0	0
ALMONDS	(000400)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	0	2	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
AVOCADO	(001000)													
-A- PETROLEUM HYDROCARBONS	00473	7	5	3	426	108	39	266	30	3	214	37	21	1159
		0	0	0	0	0	0	0	0	0	0	0	0	0
CARROT	(002200)													
-A- PETROLEUM HYDROCARBONS	00473	226	916	2065	1421	552	865	1137	1370	800	834	281	60	10526
		0	0	0	0	0	0	0	0	0	0	0	0	0
CELERY	(002600)													
-A- PETROLEUM HYDROCARBONS	00473	0	5	0	16	24	40	91	119	0	0	0	0	295
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITRUS	(003100)													
-A- PETROLEUM HYDROCARBONS	00473	171	97	129	868	536	536	334	277	66	60	331	56	3461
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITY AGENCY	(003300)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
CLOVER	(003400)													
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	215	118	2	0	0	334
		0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY AGRICULTURAL COMMISSI	(004000)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	1	5	7	27	77	4	0	15	0	4	142
		0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY ROAD	(004050)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	6	0	0	0	0	0	0	0	0	6
		0	0	0	0	0	0	0	0	0	0	0	0	0
FALLOW FARM LAND	(005000)													
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	7	0	0	0	0	0	7
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
FEDERAL AGENCY	(005100)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	1	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
FLOOD CONTROL	(005400)													
-O- PETROLEUM HYDROCARBONS	00473	0	1	11	49	12	21	0	27	32	17	0	0	170
		0	0	0	0	0	0	0	0	0	0	0	0	0
GARLIC	(005900)													
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	12	13
		0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION DISTRICTS	(007100)													
-O- PETROLEUM HYDROCARBONS	00473	0	2	1	0	16	0	0	11	3	0	0	0	32
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	2	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
LETTUCE (HEAD)	(007600)													
-A- PETROLEUM HYDROCARBONS	00473	0	7	5	3	2	1	1	0	0	0	0	0	19
		0	0	0	0	0	0	0	0	0	0	0	0	0
NON-AGRICULTURAL AREAS	(008900)													
-A- PETROLEUM HYDROCARBONS	00473	0	0	3	3	5	10	9	13	6	2	1	0	53
		0	0	0	0	0	0	0	0	0	0	0	0	0
ONIONS	(009600)													
-A- PETROLEUM HYDROCARBONS	00473	15	0	78	31	9	0	9	0	0	0	1	0	142
		0	0	0	0	0	0	0	0	0	0	0	0	0
PARSNIP	(010200)													
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	9	0	0	0	10
		0	0	0	0	0	0	0	0	0	0	0	0	0
POTATO	(011500)													
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	9	61	15	1	0	0	86
		0	0	0	0	0	0	0	0	0	0	0	0	0
RECREATIONAL AREAS	(012400)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL PEST CONTROL	(012500)													
-O- PETROLEUM HYDROCARBONS	00473	3	3	5	13	16	12	17	2	0	1	1	0	73
		0	0	0	0	0	0	0	0	0	0	0	0	0
STRAWBERRIES	(015000)													
-A- PETROLEUM HYDROCARBONS	00473	38	20	7	1	0	0	0	0	0	0	0	21	95
		0	0	0	0	0	0	0	0	0	0	0	0	0
WATER RESOURSES	(018100)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	6	0	0	0	0	0	6
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION 10 PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
AGRICULTURAL HERBICIDES TOTAL -A-		2509	5528	5184	3970	1604	1617	1891	2148	1029	1113	651	172	27416
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -D-		4	20	50	117	64	135	111	150	101	38	1	4	790
		0	0	0	0	0	0	0	0	0	0	0	0	0
INSECTICIDES														
AGENCIES, OTHER	(000200)													
-D- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-D- PETROLEUM OIL, UNCLASSIFIED	00765	1	2	0	0	0	0	2	3	1	1	1	3	15
		0	0	0	0	0	0	0	0	0	0	0	0	0
ALMONDS	(000400)													
-A- MINERAL OIL	00401	123	200	114	51	39	30	22	13	7	5	3	2	609
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	2743	2002	872	464	259	114	42	6	2	1	56	198	6758
		0	0	0	0	0	0	0	0	0	0	0	0	0
APPLE	(000600)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	10	8	12	2	2	1	0	0	0	0	0	0	35
		0	0	0	0	0	0	0	0	0	0	0	0	0
APRICOT	(000700)													
-A- MINERAL OIL	00401	0	2	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM HYDROCARBONS	00473	1	1	0	0	0	0	0	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	197	245	63	40	28	3	0	0	0	0	0	1	579
		0	0	0	0	0	0	0	0	0	0	0	0	0
AVOCADO	(001000)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	1	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
CHERRIES	(002700)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	5	9	3	2	1	0	0	0	0	0	0	0	20
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITRUS	(003100)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	1	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITRUS, OTHER	(003200)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	2	2	2	4	2	1	1	4	18	3	1	1	41
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITY AGENCY	(003300)													
-D- PETROLEUM OIL, UNCLASSIFIED	00765	0	1	2	0	0	0	0	0	0	0	0	0	4
		0	0	0	0	0	0	0	0	0	0	0	0	0
CORN	(003800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	65	37	2	1	0	0	0	0	107
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
COUNTY AGRICULTURAL COMMISST	(004000)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY ROAD	(004050)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	1	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
DECIDUOUS ORNAMENTAL TREES	(004300)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	1	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
FIGS	(005300)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	1	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
GRAPES	(006200)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	15	29	20	5	2	1	2	15	1	0	0	0	89
		0	0	0	0	0	0	0	0	0	0	0	0	0
GRAPEFRUIT	(006300)													
-A- MINERAL OIL	00401	2	1	1	1	1	1	1	12	15	5	3	2	45
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	12	11	12	15	11	8	6	39	66	117	66	30	393
		0	0	0	0	0	0	0	0	0	0	0	0	0
LEMON	(007500)													
-A- MINERAL OIL	00401	7	7	13	14	9	41	13	11	10	19	13	14	170
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	127	168	211	422	377	470	327	589	1186	709	434	362	5381
		0	0	0	0	0	0	0	0	0	0	0	0	0
NECTARINES	(008800)													
-A- MINERAL OIL	00401	8	5	3	2	1	1	0	0	0	0	0	0	20
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	280	163	68	46	23	14	4	1	4	0	0	45	648
		0	0	0	0	0	0	0	0	0	0	0	0	0
OLIVES	(009500)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	2	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	1	1	1	1	0	18	135	80	12	13	7	3	271
		0	0	0	0	0	0	0	0	0	0	0	0	0
ORANGE	(009800)													
-A- MINERAL OIL	00401	6	4	5	5	3	4	4	43	41	21	13	8	157
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	62	89	94	260	119	81	85	403	691	641	286	143	2954
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION 10 PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
PEACH	(010400)													
-A- MINERAL OIL	00401	35	31	18	10	6	5	3	2	1	1	0	0	113
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	822	572	264	118	51	26	12	2	1	0	38	95	1999
		0	0	0	0	0	0	0	0	0	0	0	0	0
PEAR	(010500)													
-A- MINERAL OIL	00401	14	17	33	25	10	8	6	5	3	36	15	5	178
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	1	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	157	296	204	129	530	202	132	60	23	13	8	14	1769
		0	0	0	0	0	0	0	0	0	0	0	0	0
PLUM	(011200)													
-A- MINERAL OIL	00401	10	15	7	4	2	2	1	1	0	0	0	0	44
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	227	221	71	39	20	6	2	0	2	9	3	9	608
		0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNE	(011800)													
-A- MINERAL OIL	00401	0	1	1	1	8	2	1	1	0	0	0	0	15
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	71	107	213	53	48	56	7	1	0	0	0	0	556
		0	0	0	0	0	0	0	0	0	0	0	0	0
RECREATIONAL AREAS	(012400)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL PEST CONTROL	(012500)													
-O- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	29	15	5	11	4	3	8	22	30	11	16	7	160
		0	0	0	0	0	0	0	0	0	0	0	0	0
SCHOOL DISTRICTS	(013300)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	16	0	0	0	16
		0	0	0	0	0	0	0	0	0	0	0	0	0
STATE HIGHWAYS	(014800)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	1	1	0	0	0	0	1	0	2	0	0	5
		0	0	0	0	0	0	0	0	0	0	0	0	0
STRAWBERRIES	(015000)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
STRUCTURAL CONTROL	(015200)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	1	0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION 10 PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
UNIVERSITY OF CALIFORNIA	(018600)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
WALNUT	(017800)													
-A- MINERAL OIL	00401	0	0	0	2	0	3	2	0	0	0	0	0	7
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	1	1	2	11	8	12	13	3	0	0	0	0	50
		0	0	0	0	0	0	0	0	0	0	0	0	0
AGRICULTURAL INSECTICIDES														
TOTAL -A-		4938	4208	2309	1725	1627	1149	824	1294	2084	1594	946	933	23631
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -O-		32	19	9	12	4	4	11	26	47	15	17	10	205
		0	0	0	0	0	0	0	0	0	0	0	0	0
FUNGICIDE+INSECTICIDE														
ALMONDS	(000400)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	2	3
		0	0	0	0	0	0	0	0	0	0	0	0	0
OLIVES	(009500)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
ORANGE	(009800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	1	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
AGRICULTURAL FUNGICIDE+INSECTICIDE														
TOTAL -A-		0	0	0	0	0	0	0	0	0	1	0	3	6
		0	0	0	0	0	0	0	0	0	0	0	0	0
HERBICIDE+INSECTICIDE														
GRAPEFRUIT	(006300)													
-A- MINERAL OIL	00401	0	1	0	0	0	0	0	0	0	0	1	0	4
		0	0	0	0	0	0	0	0	0	0	0	0	0
LEMON	(007500)													
-A- MINERAL OIL	00401	2	2	2	12	25	30	38	28	12	7	3	3	166
		0	0	0	0	0	0	0	0	0	0	0	0	0
ONIONS	(009600)													
-A- MINERAL OIL	00401	0	1	4	1	0	0	0	0	0	0	0	0	6
		0	0	0	0	0	0	0	0	0	0	0	0	0
ORANGE	(009800)													
-A- MINERAL OIL	00401	9	7	5	4	3	6	4	6	20	29	10	12	119
		0	0	0	0	0	0	0	0	0	0	0	0	0
PEACH	(010400)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	1	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
AGRICULTURAL HERBICIDE+INSECTICIDE TOTAL -A-		12	11	12	18	29	36	43	34	33	31	22	16	296
		0	0	0	0	0	0	0	0	0	0	0	0	0
DEFOLIANT AGENCIES, OTHER	(000200)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	32	0	0	0	1	6	6	1	3	0	0	50
		0	0	0	0	0	0	0	0	0	0	0	0	0
ALFALFA	(000300)													
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	2469	0	1286	243	0	0	0	3999
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	44	86	64	26	15	21	9	6	4	1	1	1	277
		0	0	0	0	0	0	0	0	0	0	0	0	0
COTTON	(003900)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	9	1	0	0	0	10
		0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION DISTRICTS	(007100)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	3	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	0
SORGHUM	(013900)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	27	3	0	0	0	30
		0	0	0	0	0	0	0	0	0	0	0	0	0
AGRICULTURAL DEFOLIANT TOTAL -A-		44	86	64	26	15	2490	9	1328	250	2	1	1	4318
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -0-		0	32	0	0	0	1	6	6	1	7	0	0	54
		0	0	0	0	0	0	0	0	0	0	0	0	0
AGRICULTURAL TOTAL -A-		7504	9833	7569	5739	3275	5292	2767	4804	3397	2740	1621	1124	55664
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -0-		36	70	59	128	68	140	128	182	150	56	18	14	1049
		0	0	0	0	0	0	0	0	0	0	0	0	0
HOME GARDEN HERBICIDES AGENCIES, OTHER	(000200)													
-0- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	1	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION DISTRICTS	(007100)													
-0- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	2	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
HOME GARDEN HERBICIDES TOTAL -0-		0	0	0	0	0	0	2	0	0	1	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
INSECTICIDES														
AGENCIES, OTHER	(000200)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	2	1	0	1	1	0	0	0	0	0	0	0	6
		0	0	0	0	0	0	0	0	0	0	0	0	0
APRICOT	(000700)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	1	1	0	0	0	0	0	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	0
CHERRIES	(002700)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	1	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITRUS, OTHER	(003200)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITY AGENCY	(003300)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
COUNTY AGRICULTURAL COMMISSI	(004000)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
DECIDUOUS ORNAMENTAL TREES	(004300)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
FLOOD CONTROL	(005400)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
GRAPES	(006200)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	1	2	1	0	0	0	0	0	0	0	0	0	5
		0	0	0	0	0	0	0	0	0	0	0	0	0
GRAPEFRUIT	(006300)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	3	0	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	0
LEMON	(007500)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	3	3	4	4	2	3	5	43	80	28	19	10	203
		0	0	0	0	0	0	0	0	0	0	0	0	0
NECTARINES	(008800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	32	29	34	7	4	2	1	1	0	0	0	0	109
		0	0	0	0	0	0	0	0	0	0	0	0	0
ORANGE	(009800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	4	1	0	3	32	37	3	1	1	82
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
ORNAMENTALS	(010000)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
PEACH	(010400)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	57	40	16	7	3	1	0	0	0	0	0	0	124
		0	0	0	0	0	0	0	0	0	0	0	0	0
PEAR	(010500)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	2	1	1	2	6	0	1	0	0	0	0	0	13
		0	0	0	0	0	0	0	0	0	0	0	0	0
PLUM	(011200)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	37	34	12	8	4	2	1	0	0	0	0	0	100
		0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNE	(011800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	1	12	10	8	2	18	1	1	0	0	0	0	53
		0	0	0	0	0	0	0	0	0	0	0	0	0
RECREATIONAL AREAS	(012400)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL PEST CONTROL	(012500)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	12	7	2	1	2	0	1	0	0	0	1	3	30
		0	0	0	0	0	0	0	0	0	0	0	0	0
SCHOOL DISTRICTS	(013300)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
SHRUBS	(013600)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
STATE HIGHWAYS	(014800)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
STRUCTURAL CONTROL	(015200)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
UNIVERSITY OF CALIFORNIA	(016600)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	2	0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
HOME GARDEN INSECTICIDES														
TOTAL -A-		134	125	80	41	22	27	12	76	119	32	20	10	697
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -0-		16	9	2	2	4	1	1	0	1	0	2	3	40
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
HOME GARDEN														
TOTAL -A-		134	125	80	41	22	27	12	76	119	32	20	10	697
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -0-		16	9	2	2	4	1	4	0	1	1	2	3	44
		0	0	0	0	0	0	0	0	0	0	0	0	0
INDUSTRIAL														
INSECTICIDES														
AGENCIES, OTHER	(000200)													
-0- PETROLEUM DISTILLATES	00763	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
CITY AGENCY	(003300)													
-0- PETROLEUM DISTILLATES	00763	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
RECREATIONAL AREAS	(012400)													
-0- PETROLEUM DISTILLATES	00763	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL PEST CONTROL	(012500)													
-0- AROMATIC PETROLEUM SOLVENTS	00752	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-0- PETROLEUM DISTILLATES	00763	0	0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
-0- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
STRUCTURAL CONTROL	(015200)													
-0- AROMATIC PETROLEUM SOLVENTS	00752	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-0- PETROLEUM DISTILLATES	00763	0	0	0	0	0	0	0	0-	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
-0- PETROLEUM HYDROCARBONS	00473	1	0	0	0	0	0	0	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	0
INDUSTRIAL														
INSECTICIDES														
TOTAL -0-		1	0	0	1	1	1	1	1	0	1	1	0	7
		0	0	0	0	0	0	0	0	0	0	0	0	0
NOT USED														
INSECTICIDES														
STRUCTURAL CONTROL	(015200)													
-0- PETRULEUM DISTILLATES	00763	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
MANUFACTORING														
INSECTICIDES														
RESIDENTIAL PEST CONTRUL	(012500)													
-0- PETRULEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
STRUCTURAL CONTROL	(015200)													
-0- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
MANUFACTORING														
INSECTICIDES														
TOTAL -O-		0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
NON-CROP														
HERBICIDES														
AGENCIES, OTHER	(000200)													
-O- AROMATIC PETROLEUM SOLVENTS	00752	0	0	0	0	0	0	0	0	5	0	0	0	5
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	6	0	0	0	1	0	0	0	0	7
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	27	1	6	9	0	45	0	0	89
		0	0	0	0	0	0	0	0	0	0	0	0	0
FEDERAL AGENCY	(005100)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	4	0	0	23	35	0	0	0	0	63
		0	0	0	0	0	0	0	0	0	0	0	0	0
IRRIGATION DISTRICTS	(007100)													
-O- AROMATIC PETROLEUM SOLVENTS	00752	0	0	0	0	13	17	32	59	22	5	0	0	146
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	168	143	0	312
		0	0	0	0	0	0	0	0	0	0	0	0	0
RECLAMATION DISTRICT	(012300)													
-O- AROMATIC PETROLEUM SOLVENTS	00752	0	0	0	0	0	2	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
RECREATIONAL AREAS	(012400)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	1	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL PEST CONTROL	(012500)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM OIL, UNCLASSIFIED	00765	1	5	12	4	1	0	1	11	3	0	0	0	37
		0	0	0	0	0	0	0	0	0	0	0	0	0
UNIVERSITY OF CALIFORNIA	(016600)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	1	5	1	0	1	0	0	0	0	0	0	8
		0	0	0	0	0	0	0	0	0	0	0	0	0
VECTOR CONTROL	(017700)													
-A- DIESEL & MISCELLANEOUS OIL	92000	6	1	5	8	3	2	13	18	11	1	13	0	80
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM HYDROCARBONS	00473	0	1	2	5	3	13	75	52	70	35	4	2	262
		0	0	0	0	0	0	0	0	0	0	0	0	0
NON-CROP														
HERBICIDES														
TOTAL -A-		6	3	6	14	6	15	88	71	81	36	16	2	343
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -O-		1	6	17	15	41	21	64	114	30	219	144	0	671
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
INSECTICIDES														
AGENCIES, OTHER	(000200)													
-O- MINERAL OIL	00401	0	0	0	11	13	20	36	67	5	14	0	1	167
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM DISTILLATES	00763	0	0	0	2	1	58	154	351	0	29	1	0	596
		0	0	0	0	0	0	0	0	0	0	0	0	0
SCHOOL DISTRICTS	(013300)													
-O- PETROLEUM DISTILLATES	00763	0	0	0	0	0	0	32	0	0	0	0	0	32
		0	0	0	0	0	0	0	0	0	0	0	0	0
VECTOR CONTROL	(017700)													
-A- DIESEL & MISCELLANEOUS OIL	92000	7	6	27	63	121	202	192	264	216	113	16	14	1241
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM DISTILLATES	00763	2	7	13	85	122	347	481	546	429	209	25	5	2273
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	14	33	32	71	59	72	82	13	3	380
		0	0	0	0	0	0	0	0	0	0	0	0	0
NON-CROP INSECTICIDES														
TOTAL -A-		8	13	40	163	276	581	745	669	718	404	54	22	3893
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -O-		0	0	0	13	14	78	221	419	5	43	1	1	795
		0	0	0	0	0	0	0	0	0	0	0	0	0
NON-CROP														
TOTAL -A-		14	16	47	177	282	596	832	940	798	440	70	24	4236
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -O-		1	6	18	28	55	99	284	533	35	262	145	1	1466
		0	0	0	0	0	0	0	0	0	0	0	0	0
SPREADER STICKER ADJUVANTS														
ALFALFA	(000300)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
APPLE	(000600)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	1	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
ARTICHOKE	(000800)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
ASPARAGUS	(000900)													
-A- MINERAL OIL	00401	0	0	0	2	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
BEANS	(001200)													
-A- MINERAL OIL	00401	0	0	0	0	0	1	3	1	0	0	0	0	4
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION 10 PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
BEETS	(001400)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
BROCCOLI	(001700)													
-A- MINERAL OIL	00401	0	1	1	1	1	0	1	6	8	3	1	1	23
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	1	0	0	0	0	1	2	0	0	0	5
		0	0	0	0	0	0	0	0	0	0	0	0	0
BRUSSELS SPROUTS	(001800)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
CABBAGE	(002100)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	1	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
CARROT	(002200)													
-A- MINERAL OIL	00401	0	0	1	1	1	0	1	2	0	0	0	0	6
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM HYDROCARBONS	00473	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
CAULIFLOWER	(002500)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
CELERY	(002600)													
-A- MINERAL OIL	00401	0	0	0	1	2	2	4	7	3	0	0	0	18
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	1	1	1	1	1	2	0	0	0	6
		0	0	0	0	0	0	0	0	0	0	0	0	0
COLLARD	(003600)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
CORN	(003800)													
-A- MINERAL OIL	00401	0	0	0	0	16	9	0	0	0	0	0	0	26
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	1	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
COTTON	(003900)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	3	1	0	0	4
		0	0	0	0	0	0	0	0	0	0	0	0	0
LETTUCE (HEAD)	(007600)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION 10 PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
ONIONS	(009600)													
-A- MINERAL OIL	00401	0	0	1	3	4	2	1	0	0	0	0	0	11
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	1	0	0	0	1	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
ORANGE	(009800)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
PARSLEY	(010100)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
PEPPERS (BELL)	(010800)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
POTATO	(011500)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	1	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
STRAWBERRIES	(015000)													
-A- MINERAL OIL	00401	1	5	1	1	0	0	0	0	0	0	0	0	9
		0	0	0	0	0	0	0	0	0	0	0	0	0
SUGARBEET	(015500)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	4	1	0	5
		0	0	0	0	0	0	0	0	0	0	0	0	0
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOMATO	(016200)													
-A- MINERAL OIL	00401	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
SPREADER STICKER ADJUVANTS														
TOTAL -A-		1	7	5	10	27	17	11	18	20	9	3	1	129
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -D-		0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
HERBICIDES														
BROCCOLI	(001700)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	1	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
CABBAGE	(002100)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
COLE CROPS	(003500)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
SPREADER STICKER														
HERBICIDES														
TOTAL -A-		0	0	0	1	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
INSECTICIDES														
AGENCIES, OTHER	(000200)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
ALMONDS	(000400)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	38	27	11	5	2	0	0	0	0	0	0	4	86
		0	0	0	0	0	0	0	0	0	0	0	0	0
APPLE	(000600)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	1	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
APRICOT	(000700)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
CHERRIES	(002700)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	0	0	0	0	0	0	0	0	0	0	0
GRAPES	(006200)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	1	1	1	0	0	0	0	0	0	0	0	0	3
		0	0	0	0	0	0	0	0	0	0	0	0	0
ORANGE	(009800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
PEACH	(010400)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	67	63	50	12	4	13	1	0	0	0	0	76	286
		0	0	0	0	0	0	0	0	0	0	0	0	0
PEAR	(010500)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	6	13	8	3	3	2	1	1	0	0	0	0	37
		0	0	0	0	0	0	0	0	0	0	0	0	0
PLUM	(011200)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0
PRUNE	(011800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	10	26	188	40	22	7	2	0	0	0	0	0	295
		0	0	0	0	0	0	0	0	0	0	0	0	0
RESIDENTIAL PEST CONTROL	(012500)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	1	1	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION TO PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
UNIVERSITY OF CALIFORNIA	(016600)													
-O- PETROLEUM OIL, UNCLASSIFIED	00765	2	0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
WALNUT	(017800)													
-A- PETROLEUM OIL, UNCLASSIFIED	00765	0	0	5	2	0	0	0	0	0	0	0	0	8
		0	0	0	0	0	0	0	0	0	0	0	0	0
SPREADER STICKER														
INSECTICIDES														
TOTAL -A-		122	130	264	64	31	22	4	1	1	0	0	80	719
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -O-		2	1	0	0	0	0	0	0	0	0	0	0	4
		0	0	0	0	0	0	0	0	0	0	0	0	0
SPREADER STICKER														
TOTAL -A-		123	137	269	74	58	39	15	20	21	9	3	81	849
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -O-		2	1	0	0	0	0	0	0	0	0	0	0	4
		0	0	0	0	0	0	0	0	0	0	0	0	0
GENERAL WEED CONTROL														
HERBICIDES														
SCHOOL DISTRICTS	(013300)													
-O- DIESEL & MISCELLANEOUS OIL	92000	68	55	133	144	132	87	32	172	107	75	56	10	1070
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM HYDROCARBONS	00473	139	113	270	312	272	180	66	351	213	150	118	19	2203
		0	0	0	0	0	0	0	0	0	0	0	0	0
WEED CONTROL UNCLASSIFIED	(018105)													
-O- DIESEL & MISCELLANEOUS OIL	92000	44	161	471	312	1178	2597	1342	2531	1195	313	61	0	10153
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM HYDROCARBONS	00473	7063	1496	3388	24511	15105	15114	9590	7972	4781	1804	10779	199	101802
		0	0	0	0	0	0	0	0	0	0	0	0	0
GENERAL WEED CONTROL														
HERBICIDES														
TOTAL -O-		7314	1824	4262	25279	16687	17928	11029	11026	6295	2341	11015	229	115228
		0	0	0	0	0	0	0	0	0	0	0	0	0
INSECTICIDES														
SCHOOL DISTRICTS	(013300)													
-O- PETROLEUM HYDROCARBONS	00473	0	0	0	1	0	0	0	1	0	0	0	0	4
		0	0	0	0	0	0	0	0	0	0	0	0	0
WEED CONTROL UNCLASSIFIED	(018105)													
-O- DIESEL & MISCELLANEOUS OIL	92000	0	0	0	0	0	0	0	0	0	0	0	0	2
		0	0	0	0	0	0	0	0	0	0	0	0	0
-O- PETROLEUM HYDROCARBONS	00473	7	1	3	24	14	14	9	7	2	2	10	0	94
		0	0	0	0	0	0	0	0	0	0	0	0	0
GENERAL WEED CONTROL														
INSECTICIDES														
TOTAL -O-		7	2	4	24	15	15	9	9	2	2	11	0	99
		0	0	0	0	0	0	0	0	0	0	0	0	0

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EMISSION FROM FORMULATION 10 PESTICIDE OILS IN 1977 IN THE STATE OF CALIFORNIA (TIMES 1000)

	CODES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
GENERAL WEED CONTROL														
TOTAL -O-		7321	1826	4266	25303	16702	17993	11038	11034	6298	2343	11025	229	115327
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -A-		7776	10110	7964	6031	3636	5954	3626	5839	4335	3221	1713	1239	61445
		0	0	0	0	0	0	0	0	0	0	0	0	0
TOTAL -O-		7376	1911	4345	25463	16830	18183	11456	11750	6483	2663	11190	248	117897
		0	0	0	0	0	0	0	0	0	0	0	0	0

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A.2.2.2 Creosote Emissions

A.2.2.2.1 Development of a Creosote Emission Factor

Evaporation has long been recognized as a major cause of creosote depletion from treated poles in storage and in line. Studies of creosote depletion caused primarily by evaporation from poles in storage stocks have shown that on the average as much as 50 percent or more is lost within 3-5 years.[1]

A laboratory evaporation test was included as a part of the 1958 Cooperative Creosote Project.[2] The different straight, fortified and blended creosote solutions that were evaluated during the test are presented below.

Physical Characteristics of Preservatives in 1958 Cooperative Creosote Project[2]

Sample	A	B	C	D	E	F	G	H	I	J	K
Description	Creo.	Creo. A with 2% Penta	Creo.	Creo.	Creo. D with 2% Penta	Creo.	Creo.	70% A with 30% Coal Tar	70% D with 30% Coal Tar	50% A with 50% Petroleum Oil	50% D with 50% Petroleum Oil
Water, %	0.3	0.1	Trace	0.3	0.1	0.1	0.7	0.5	1.1	1.2	0.8
Benzene Insoluble, %	0.1	0.2	0.1	0.1	0.2	0.2	0.2	2.5	2.6	0.6	0.4
Coke Residue, %	1.1	2.6	0.6	0.8	3.0	0.8	0.8	6.6	6.9	7.4	7.1
Viscosity at 210° F. (cp calc.)	1.46	1.77	1.65	1.84	2.15	2.27	2.11	2.75	3.02	4.35	5.56
Specific Gravity, 38.0°/15.5° C.											
Whole Oil	1.070	1.087	1.082	1.092	1.106	1.108	1.105	1.100	1.113	1.057	1.069
235° to 315° C. fraction	1.039	1.055	1.048	1.065	1.070	1.058	1.066	1.038	1.048	1.018	1.026
316° to 355° C. fraction	1.113	1.117	1.117	1.119	1.128	1.115	1.119	1.109	1.116	1.049	1.065
Distillation (AWPA A 1) Weight percent to:											
210° C.	0.8	0.0	....	......	......	......	.	0.5	0.3	0.5	0.2
235° C.	10.3	6.3	0.0	0.0	0.0	0.0	0.0	8.7	1.0	3.4	0.4
270° C.	40.9	36.2	24.1	12.7	12.4	4.4	5.2	32.9	17.1	20.4	5.6
315° C.	63.5	60.0	58.5	52.0	49.7	31.5	40.3	50.4	43.7	37.7	28.3
355° C.	82.2	79.4	81.8	82.2	79.7	72.2	78.0	67.3	66.7	51.4	51.3
Residue at 355° C.	17.4	20.3	18.8	17.4	20.2	27.7	21.5	32.2	33.0	48.0	48.6
Residue at 400° C.	8.4	10.5	4.8	4.1	.....	5.6	4.8		...	.....	..
Distillation (5-ball column) Weight percent to:											
210° C.	6.3	...	1.0	0.7	.	0.9	1.7	5.4	2.7	2.3	1.1
230° C.	25.7	....	6.4	4.8	....	4.6	5.4	21.0	9.3	10.4	3.4
270° C.	45.6	..	35.1	26.8	.....	14.2	15.6	37.2	27.4	24.7	14.4
315° C.	65.0	.....	59.4	54.6	......	42.0	45.1	53.3	48.5	38.9	31.7
355° C.	81.8	.. .	80.6	80.0	.....	72.0	76.1	69.0	68.9	69.9	71.9
Residue (by difference)	18.2	......	19.4	20.0	.....	28.0	23.9	31.0	31.1	30.1	28.1

Post sections treated with the creosotes and creosote-penta solutions to retentions of about 8 pcf by the empty cell process were open-stocked indoors and weighed periodically over a period of 7 years to determine vapor losses. The results of the evaporation tests are shown in Table A2

The data show that the vapor loss pattern is in most cases already set after one week of exposure and is correlated with the amount of distillate below 270°C and the amounts of distillation residue at 355° and 400°C.[2]

Oil	A Avg.	A s	B Avg.	B s	C Avg.	C s	D Avg.	D s	E Avg.	E s	F Avg.	F s	G Avg.	G s
Retention, % (a)	20.2	4.8	18.2	3.0	20.6	4.2	19.0	5.3	20.2	2.9	23.9	5.7	24.5	5.6
Vapor Loss, % (b)														
1 week	8.5	1.0	7.6	2.9	7.9	2.2	6.1	1.6	3.8	1.4	4.2	1.6	5.5	2.0
3 weeks	18.5	2.7	15.9	3.7	15.1	3.9	13.8	2.8	9.7	2.7	9.5	2.2	11.7	2.3
9 weeks	30.9	6.1	27.3	4.9	26.0	5.5	24.9	5.0	17.8	2.8	16.6	2.3	21.0	2.2
1 year	37.5	2.8	32.8	3.9	35.9	4.6	30.1	3.7	21.6	2.2	21.8	2.7	27.7	3.9
5 years	41.8	2.2	33.9	2.6	41.9	3.6	34.1	2.6	25.4	2.7	26.5	1.6	33.4	2.0
7 years	45.7	2.3	38.2	2.8	46.2	3.7	38.6	3.9	30.3	3.5	30.4	2.9	37.5	2.5

(a) Based on original weight of untreated post sections.
(b) Based on preservative retention after bleeding loss.
Number of posts in each group = 6.

The effect of the addition of 2 percent pentachlorophenol in reducing vapor loss is of special interest. The post sections with creosote-penta solutions B and E lost about 8 percent less in 7 years than those with creosote A and D respectively which were used for making the solutions. The reason could be the formation of high-boiling reaction or condensation products. Though thermally unstable, the presence of such products in creosote would lower its vapor pressure and thus slow down vapor loss.[2]

In another study of creosote treatment in 1954,[3] about 150 seasoned and green southern pine poles were treated to different nominal retentions with low-residue (20 percent residue) or high-residue (40 percent residue) creosote and subjected to various after treatments. The 10-foot top and bottom sections of each pole were installed in a Florida test plot; the middle section was analyzed to determine retention and distribution of preservative. Three years later, top and bottom sections from 36 of the poles were selected at random from replicate, pulled and analyzed at above groundline and below groundline locations. After an additional 7 years, top and bottom sections from 24 other poles were removed and analyzed but only at the groundline location. The major conclusions drawn from the groundline analyses of the pole sections exposed for 3 years were confirmed by the results of the analyses of the group exposed for 10 years, and the following was concluded with complete confidence:

1) Movement of creosote and creosote residual into the outer 1/8 in., the 1/8 to 1/2 in., and the 1/2 to 2 in. zones immediately at and below the groundline is a major factor in the long-time preservation of southern pine poles against decay and insect attack.

2) Movement of creosote and creosote residual into the groundline location continues for more than 3 years after installation of the poles.

3) Movement of creosote and creosote residual is more pronounce in poles treated in seasoned condition than in poles treated in green condition. Since bleeding can be regarded as visible evidence of movement, the greater movement in seasoned poles substantiates the generally accepted observation that bleeding is more severe in seasoned poles.

4) Movement of creosote and creosote residual usually increases with retention. Even substandard poles containing 5 pcf or less creosote by boring assay show definite movement of preservative towards the goundline; however, the movement is insufficient to protect such poles. The lack of an adequate reservoir of creosote or creosote residual above the groundline accounts, at least in part, for the early failure of substandard poles.

5) Movement of creosote and creosote residual into the groundline location is usually greatest in the outer 1/8 in. zone and smallest in the 1/2 to 2 in. zone.

6) Vapor loss from all groundline zones of southern pine poles treated with 20 percent-residue creosote was high, averaging about 9 percent per

year over the first three years of exposure, about 4 percent over 10 years. The volatile constituents serve a twofold purpose, (1) they are a carrier for the higher-boiling components, ensuring deep penetration of these more permanent toxic materials into the wood, and (2) they tend to hold crystalline components of creosote in solution during storage. The volatile components are even more toxic than the higher-boiling ones and an effective percentage of the former remains in the wood for a great many years. Their eventual loss should not be alarming, for minimum retentions specified for creosote take such losses into account. These retentions are based on long-time field and service tests where the creosote in the specimens is subject to the same or sometimes even higher vapor loss.

7) Vapor loss from creosoted poles is:

(a) higher from seasoned poles than from green poles;

(b) higher from poles with lower retention;

(c) higher from outer zones than from inner zones;

(d) higher from low-residue creosote than from high-residue creosote; and

(e) on continued exposure the above differences become smaller.

In a continuation study[4] of the creosote treatment of seasoned and green southern pine poles, the effect of variables on vapor loss and movement of oil was examined. The movement and vapor loss data for the outer 2 inches of all pole sections treated with low-residue and high-residue creosote are summarized below.

Movement and Vapor Loss for Outer 2-in. Zone[4]

Creosote	Low-Residue			High-Residue		
Wood	Seas.	Green	Av.	Seas.	Green	Av.
Vapor loss during impregnation, Percent	6.2	2.8	4.1	5.8	1.4	3.2
Original retention, lb. per cu. ft.	7.65	12.17	9.91	7.75	9.59	8.67
Adjusted retention, lb. per cu. ft.	6.83	10.02	8.43	6.45	8.73	7.60
Retention after 8 years, lb. per cu. ft.	4.95	8.50	6.73	5.79	8.35	7.07
Movement loss (a), Percent	10.7	17.7	14.9	17.1	9.0	12.6
Vapor loss (b), Percent	27.5	15.2	20.2	10.3	4.4	7.0

(a) Based on original retention.
(b) Based on adjusted retention.

The data show the net change in average retention for the outer 2 inch zone of the pole sections during exposure for 3 years, broken down into movement of creosote, which can result in a gain or loss, and vapor loss. Vapor loss before extraction of freshly-treated poles based on change in percentage of residue is considerable, averaging about 4 percent in the case of low residue creosote and about 3 percent for high residue creosote.

Vapor loss from the seasoned and green pole sections treated with low-residue is almost three times as large as from those treated with high-residue creosote (20.2 percent vs. 7.0 percent). Vapor loss from seasoned wood is about twice as high as that from green wood for both creosotes (27.5 percent vs. 15.2 percent and 10.3 percent vs. 4.4 percent).

The following conclusions were arrived at from the study:

1) Vapor loss from green pole sections is much smaller than from similarly treated seasoned pole sections;

2) Vapor loss above groundline and at groundline are about the same;

3) Vapor losses below groundline and from the 1/2 to 2 in. zone of the pole sections are relatively small, particularly in the case of the 40 percent residue creosote;

4) Vapor losses greatly increase in the outer zones of a pole section;

5) Vapor loss from pole sections treated with 20 percent residue creosote is much larger than from those treated with 40 percent residue creosote;

6) Going from the outer towards the inner zone of pole section, vapor loss from the higher residue creosote decreases more rapidly than vapor loss from the lower residue creosote;

7) Going from the outer towards the inner zone of a pole section, vapor loss decreases more rapidly for green pole sections than for seasoned ones; and

8) Creosote and creosote residual move downwards in all zones of a pole section. As a result, the adjusted retention is generally greatest at the groundline, slightly lower below the groundline, and very much lower above the groundline.

It is realized that the above conclusions are based on data obtained with 10 ft. sections of normal-diameter poles. The observed downward, outward and inward movement of creosote and creosote residual should be even more pronounced with full-length poles. Vapor loss percentages at the three locations should not be affected by the length of the pole, but since a greater percentage of the full-length pole is above groundline where vapor losses are most severe overall losses might be greater.[4]

A.2.2.2.2 Emissions from Creosote Use in California

Creosote and creosote/petroleum emissions were discussed in Section 6.2.4 and determined to be 10 percent of the amount of preservative used. Table A.2-8 details the emissions associated with the creosote and creosote/petroleum use. Additionally, the 11 tons of creosote emissions associated with the four treatment plants have been distributed among the four counties where the plants are located

TABLE A.2-8 1977 MONTHLY DISTRIBUTION OF CREOSOTE AND CREOSOTE/PETROLEUM EMISSIONS BY COUNTY IN CALIFORNIA (LBS.)

COUNTY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Alameda	3,612	3,612	5,056	2,167	10,113	4,334	5,056	12,280	9,390	5,056	4,334	7,223	72,233
Alpine	0	0	0	0	0	0	0	0	0	0	0	0	0
Amador	305	305	428	183	855	367	428	1,038	794	428	367	611	6,109
Butte	3,197	3,197	4,475	1,918	8,950	3,836	4,475	10,868	8,311	4,475	3,836	6,393	63,931
Calaveras	372	372	521	223	1,014	446	521	1,264	967	521	446	744	7,438
Colusa	1,301	1,301	1,822	781	3,644	1,562	1,822	4,424	3,383	1,822	1,562	2,603	26,027
Contra Costa	2,948	2,948	4,127	1,769	8,254	3,537	4,127	10,022	7,664	4,127	3,537	5,896	58,956
Del Norte	0	0	0	0	0	0	0	0	0	0	0	0	0
El Dorado	558	558	781	335	1,562	669	781	1,896	1,450	781	669	1,115	11,155
Fresno	2,271	2,271	3,179	1,362	6,358	2,725	3,179	7,720	5,904	3,179	2,725	4,541	45,414
Glenn	1,102	1,102	1,543	661	3,086	1,323	1,543	3,747	2,865	1,543	1,323	2,204	22,042
Humboldt	1,474	1,474	2,063	884	4,127	1,769	2,063	5,011	3,832	2,063	1,769	2,948	29,477
Imperial	3,705	3,705	5,186	2,223	10,373	4,446	5,186	12,596	9,632	5,186	4,446	7,409	74,093
Inyo	1,102	1,102	1,543	661	3,086	1,323	1,543	3,747	2,865	1,543	1,323	2,204	22,042
Kern	7,542	7,542	10,559	4,525	21,117	9,050	10,559	25,643	19,609	10,559	9,050	15,084	150,839
Kings	1,195	1,195	1,673	717	3,346	1,434	1,673	4,063	3,107	1,673	1,434	2,390	23,900
Lake	0	0	0	0	0	0	0	0	0	0	0	0	0
Lassen	4,076	4,076	5,707	2,446	11,414	4,892	5,707	13,860	10,599	5,707	4,892	8,153	81,529
Los Angeles	17,408	17,408	24,371	10,445	48,741	20,889	24,371	59,186	45,260	24,371	20,889	34,815	348,154
Madera	1,102	1,102	1,543	661	3,086	1,323	1,543	3,747	2,865	1,543	1,323	2,204	22,042
Marin	558	558	781	335	1,562	669	781	1,896	1,450	781	669	1,115	11,155
Mariposa	0	0	0	0	0	0	0	0	0	0	0	0	0
Mendocino	2,032	2,032	2,844	1,219	5,688	2,438	2,844	6,907	5,282	2,844	2,438	4,063	40,631
Merced	2,231	2,231	3,123	1,338	6,246	2,677	3,123	7,584	5,800	3,123	2,677	4,461	44,614
Modoc	3,147	3,147	4,406	1,888	8,811	3,776	4,406	10,700	8,182	4,406	3,776	6,294	62,939
Mono	0	0	0	0	0	0	0	0	0	0	0	0	0
Monterey	2,948	2,948	4,127	1,769	8.254	3,537	4.127	10.022	7,664	4,127	3,537	5,896	58,956
Napa	757	757	1,060	454	2,119	908	1,060	2,573	1,968	1,060	908	1,514	15,138
Nevada	372	372	521	223	1,041	446	521	1,264	967	521	446	744	7,438
Orange	3,333	3,333	4,666	2,000	9,332	3,999	4,666	11,332	8,665	4,666	3,999	6,666	66,657
Placer	2,231	2,231	3,123	1,338	6,246	2,677	3,123	7,584	5,800	3,123	2,677	4,461	44,614
Plumas	2,231	2,231	3,123	1,338	6,246	2,677	3,123	7,584	5,800	3,123	2,677	4,461	44,614
Riverside	5,192	5,192	7,268	3,115	14,537	6,230	7,268	17,652	13,499	7,268	6,230	10,383	103,834
Sacramento	3,333	3,333	4,666	2,000	9,332	3,999	4,666	11,332	8,665	4,666	3,999	6,666	66,657
San Benito	651	651	911	390	1,822	781	911	2,212	1,692	911	781	1,301	13,014
San Bernadino	12,216	12,216	17,102	7,330	34,204	14,659	17,102	41,534	31,761	17,102	14,659	24,432	244,317
San Diego	3,705	3,705	5,186	2,223	10,373	4,446	5,186	12,596	9,632	5,186	4,446	7,409	74,093
San Francisco	213	213	297	128	595	255	297	722	552	297	255	425	4,249
San Joaquin	3,931	3,931	5,503	2,358	11,005	4,717	5,503	13,364	10,219	5,503	4,717	7,861	78,612
San Luis Obispo	1,102	1,102	1,543	661	3,086	1,323	1,543	3,747	2,865	1,543	1,323	2,204	22,042
San Mateo	1,022	1,022	1,431	613	2,863	1,227	1,431	3,476	2,658	1,431	1,227	2,045	20,446
Santa Barbara	2,603	2,603	3,644	1,562	7,287	3,123	3,644	8,849	6,767	3,644	3,123	5,205	52,054
Santa Clara	1,859	1,859	2,603	1,115	5,205	2,231	2,603	6,320	4,833	2,603	2,231	3,718	37,180
Santa Cruz	1,102	1,102	1,543	661	3,086	1,323	1,543	3,747	2,865	1,543	1,323	2,204	22,042
Shasta	1,474	1,474	2,063	884	4,127	1,769	2,063	5,011	3,832	2,063	1.769	2,948	29,477
Sierra	186	186	260	112	521	223	260	632	483	260	223	372	3,718
Siskiyou	3,367	3,367	4,714	2,020	9,427	4,040	4,714	11,447	8,754	4,714	4.040	6,734	67,338
Solano	1,859	1,859	2,603	1,115	5,205	2,231	2,603	6,320	4,833	2,603	2,231	2,718	37.180
Sonoma	1,288	1,288	1,803	773	3,606	1,546	1,803	4,379	3,349	1,803	1,546	2,576	25,760
Stanislaus	2,775	2,775	3,885	1,665	7,770	3,330	3,885	9,435	7,215	3,885	3,330	5,550	55,500
Sutter	916	916	1,283	550	2,565	1,099	1,283	3,115	2,382	1,283	1,099	1,832	18,323

TABLE A.2-8 (cont'd)

COUNTY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Tehama	916	916	1,283	550	2,565	1,099	1,283	3,115	2,382	1,283	1,099	1,832	18,323
Trinity	186	186	260	112	521	223	260	632	483	260	223	372	3,718
Tulau	4,807	4,807	6,729	2,884	13,459	5,768	6,729	16,343	12,497	5,729	5,768	9,613	96,133
Tuolummi	478	478	669	287	1,338	574	669	1,625	1,243	669	574	956	9,560
Ventura	2,788	2,788	3,904	1,673	7,808	3,346	3,904	9,481	7,250	3,904	3,346	5,577	55,769
Yolo	1,859	1,859	2,603	1,115	5,205	2,231	2,603	6,320	4,833	2,603	2,231	3,718	37,180
Yuba	916	916	1,283	550	2,565	1,099	1,283	3,115	2,382	1,283	1,099	1,832	18,323
TOTAL	133,854/	133,854/	187,390/	80,309/	374,775/	160,621/	187,390/	455,079/	348,001/	187,390/	160,621/	267,695	2,676,979

A.2.3 References

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A.3.0 USE PATTERNS AND ALTERNATIVES TO PESTICIDE OIL USE

A.3.1 Agricultural Use

A.3.1.1 Citrus Crops

A.3.1.1.1 Introduction

Some 290 thousand acres were in citrus crops in California in 1977. Of this, 51 percent was located in the San Joaquin Valley and 47 percent in Southern California. The four major citrus varieties grown in California are grapefruit, lemon, navel oranges and Valencia oranges. Most of the grapefruit (89%) and lemon acreage (79%) and more than half of the Valencia orange acreage (57%) is in Southern California.[1]

A.3.1.1.2 The Pest Problem in Relation to Oil Usage

In the 1976-1978 Treatment Guide for California Citrus Crops,[2] petroleum oil is recommended for control of 10 species of insects and mites and for citrus aphids. Included in this list are three to four major pests of citrus in California. These are California red scale, *Aonidiella aurantii* (Mask.), citrus red mite, *Panonychus citri* (McG.) and the citrus bud mite, *Eriophyes sheldoni* (Ewing).[3] The 4th major citrus pest, the citrus thrips, *Scirtothrips citri* (Moult.) is not controlled by oil sprays. The other insect and mite pests which can be controlled by oil rarely cause serious problems because their numbers are usually kept low either by predators and parasites or by the control treatments applied for the major pests.[4]

Large economic losses can result from heavy infestations of each of the major pests, especially the California red scale.[5]

California red scale attacks all parts of the tree: leaves, fruit, twigs, branches and trunk. Defoliation, branch die-back and death of the tree can occur if the scale is not suppressed. A lighter infestation leads to the culling of infested fruit and reduced yields.[7]

The citrus red mite feeds on the fruit, the leaves and the green bark of grapefruit, orange and lemon trees although lemon appears to be the preferred host. The fruit surface can be marred, thereby leading to reduced grade or culling of fruit. There may be increased fruit drop and a decrease in fruit size and yield. Defoliation of the last flush of new growth often results from severe infestations of red mite.[6]

The citrus bud mite is a problem only on lemon trees. The mites feed primarily on buds. The fruit or leaf buds may be completely destroyed. In less severe cases, developing leaves and fruit may show varying degrees of deformity which lead to serious crop losses.[7]

There are other pest species, scales, mites and aphids which can increase to serious pest status either from unknown causes or because predator and parasite populations were reduced by applications of pesticide.[4,8]

Citrus pest problems and effective methods to control the pests differ in relation to the citrus variety and geographic region. In the San Joaquin Valley, the major pests are California red scale, citricola scale, citrus thrips and citrus red mite. Major pests in the South Coast area are California red scale, citrus thrips, citrus red mite and on lemon trees, the citrus bud mite. The major problems in the interior desert areas of Southern California are from California red scale, citrus thrips and citrus red mite.[3,5,9] The non-uniform distribution of citrus pest problems in different regions of California is largely associated with climatic differences especially the extremes of temperature and humidity. The climate affects the pest species and the predatory and parasitic beneficial insects which help to keep pest population under control.[3,10]

California red scale is much less a problem in some coastal areas such as parts of Ventura and Orange Counties than in the Central Valley which suffers greater extremes of summer and winter temperatures and have longer periods of low humidity. In some parts of Ventura County (perhaps 20% of citrus acreage), no treatment is required for red scale.[11]

In the San Joaquin Valley, California red scale usually requires treatment every year and the treatment usually involves the use of synthetic pesticides such as parathion since oil may damage trees during hot weather.[4]

A.3.1.1.3 Application Rates

The reported nonsynthetic hydrocarbon oils are applied to citrus trees almost entirely as a treatment for the control of scale insects and mites. The preferred application time for control of scale insects and mites in Southern California is August through October for orange and September through November for lemons.[12,13] May and June are recommended for citrus bud mite on lemon. Low volume oil sprays for mites on lemons are recommended in the coastal district at any time and from March through June in the interior of Southern California. The distribution of oil applied may be adequately accounted for in terms of applications made in accordance with these recommendations.

For either scale insects or mites, the oil spray is applied at a rate of 1.2 to 1.8 percent in water. Total coverage (TC) applications are recommended for scale insects and as an alternative for mites. This means that trees are sprayed to the point of some runoff from all parts of the tree in order to obtain an oil film coverage on all parts of the fruits, branches and leaves.

Spraying for total coverage is usually done in California with a high pressure oscillating boom sprayer which has several nozzles on a tower up to 25 feet high.[11] From about 1,200 to more than 2,000 gallons per acre of 1.5% oil spray is applied in mature orchards. If the average gallonage is taken to be 1,600, then 24 gallons or 173 pounds of oil is applied per acre of mature citrus.

Usually effective control of pests of citrus, especially red scale, cannot be obtained if the quantity of oil is reduced below the recommended rates.[14,15] However, recent experiments have shown that through the use of an airblast sprayer with an air tower about 25 percent less oil is effective.[3,16] Some growers are now using the improved sprayers with lower rates of application. This use in Ventura County may be about 10 percent of total use.[11]

In some cases, oil is used at less than recommended rates in combination with synthetic chemicals even though the oil would act more as a spreader-sticker than a fully active pesticide under these conditions.[15] The average reported application of 4.6 gallons per acre for the San Joaquin Valley in 1977 illustrates the wide use of this low volume oil application.

It was estimated above that 1,600 gallons per acre was the average amount of spray applied in mature orchards. If the average gallonage for immature orchards is 1,000 gallons per acre and one forth of the acreage is immature, then the overall average is about 1,500 gallons of spray or 152 pounds of oil per acre. It has been estimated that where oil spray applications to citrus are used, they average about 1.25 per year.[11,17] We estimate from this that the average application rate is (162 x 1.25) or 202 pounds per acre per year.

A.3.1.1.4 Advantages and Disadvantages of Oil Use

There are a number of advantages to oil use in citrus pest control which have led to its continued use and suggest the desirability of its continued availability.

Advantages

1. Cost. The relatively low cost of oil may be an advantage. The use of oil on citrus crops started in about 1901 at a time when there were few substitute pesticides available.[3] Since that time, an advantage of considerable importance as an inducement to its use was that until recently the cost of oil was low. At present the cost of oil per acre is similar to the cost of alternative chemicals.
2. Range of species effectiveness. In some cases an oil treatment will suppress more than one pest which would otherwise require a separate treatment. This may also be true with certain synthetic chemicals. However, in

the lemon crop, for example, oil is effective in control of the citrus bud mite as well as the two other major pests; red scale and citrus red mite. The only other treatment recommended for bud mite is chlorobenzilate which does not control either the citrus red mite or the red scale.

3. Low toxicity. Although oil is effective against a number of arthropod pests of citrus, it is generally not harmful to mammals and most forms of life.[18,19] Oil-sprayed orchards may be entered at any time since there are no limitations on re-entry.

4. Compatability with biological control. Oil use does not generally upset the biological control activities of the predators and parasites of arthropod pests in the way that other chemicals are known to do.[7,20] Oil pesticides can therefore be helpful as a bridge in attempts to shift from chemical to biological pest control in citrus.

5. Pest resistance. No resistance to the insecticidal effectiveness of petroleum oils has yet developed although they have been used in citrus for more than 50 years. Resistance to a number of other chemicals has developed in at least six citrus pests.[20]

Tree injury resulting from oil spray has been the primary disadvantage of the use of oil spray. The kinds of injury that have developed are (1) leaf drop, (2) fruit drop, (3) fruit burn,

(4) dead twigs and branches and (5) impaired fruit quality.[6] Most of the injury was formerly caused by the use of oils with excessive phytotoxic properties. Newer oil purification procedures have eliminated most of the tree and fruit injury if oil is applied according to recommended methods.[3,19] These recommendations stipulate oil should not be applied during very low humidity, high temperature, or to trees suffering water deficit.

A.3.1.1.5 Synthetic Organic Pesticides

The pests of citrus which are controlled by petroleum oil can also be controlled by synthetic pesticides. Most of them are in fact being controlled by synthetics in some areas. In the San Joaquin Valley, for example, where most of the orange crop is grown, there is not much oil used although two out of three key pests are the same as in other areas. The key pests which can be controlled by oil are California red scale, citricola scale, citrus red mite and citrus bud mite. Citricola scale is usually controlled by the required treatments for red scale.[2]

For each of the key citrus pests in California which can be controlled by petroleum oil, (excluding the citrus bud mite) there is more than one available synthetic pesticide alternative (Table A.3-1). Chlorobenzilate is the only synthetic pesticide recommended for control of the citrus bud mite.

Under present conditions each of the key pests of citrus will require treatment on about two-thirds of the citrus acreage.[11,17] Where oil is used, the scale insects and mites can be controlled

TABLE A.3-1

Application Rates for Recommended Synthetic Pesticide

Alternatives to Petroleum Oil for Pest Control in Citrus

(Applications in Average Pounds Per Acre)

Pesticde	K California Red Scale Yellow Scale Purple Scale	Black Scale	Citricola Scale	Brown Soft Scale	K Citrus Red Mite Pacific Mite Two-Spotted Mite	K Citrus Bud Mite	Citrus Aphids
Parathion	TCD 4.8 LV 3.6	TC 5.8	TC 5.1 MS 1.5				
Malathion	TC 10.5	TC 9.4	TC 8.7	TC 9.4			OC 1.6
Parathion & Malathion	TC 3.6 5.0	TC 3.6 +5.8	TC 3.6 +5.2	TC 3.6 +5.8			
Carbaryl	TC 12.7	TC12.7		TC 6.9			
Guthion	TC 6.5	TC 5.8		TC 6.5			
Supracide	TD 2.5						
Omite					LV 4.5 TDC 3.2		
Plietran					LV 1.5 TDC 1.4		
Morestan					OC 1.0		
Vendex					LV 1.75 TDC 1.9		
Chlorobenzine						MS, LV 1.5 TD 1.7	
Kelthane					MS or LV 4.0 TDC 4.0		
Rotenone						OC 0.1	

K - Designates group containing key pest.
TC - Total coverage spray. Trees,sprayed to runoff.
( ) - Total distribution about 70 percent of TC spray.
OC - Outside coverage spray.
LV - Low volume spray
MS - Mist spray

by, on the average, one and one-fourth oil treatments per year.[11,16,17]

If synthetic pesticides are used on citrus as an alternative to petroleum, each of the key pests must receive chemical spray treatment each year, though in some cases it may be possible to combine treatments for scale and mites.[21] It can be seen from the recommendations in Table A.3-1 that a separate synthetic pesticide will be required each year for scale insects, for citrus red mite and on lemon for citrus bud mites. Table A.3-2 summarizes data from Table A.3-1 to show the amount of synthetic pesticide required annually to substitute for oil use on citrus. There is an estimated reduction of 90 to 98 percent in pounds applied through use of the synthetic pesticide alternative.

A.3.1.1.6 Biological Control

Biological control is an important element in any consideration of pest control in citrus crops. The Southern California citrus region was the site of the first dramatic suppression of a serious economic pest through the importation of a natural enemy. This was accomplished in 1879 through importation of the vadalia beetle which completely controlled the cotteny-cushion scale.[22] Since that time, there have been more successful applications of biological control against citrus pests than against pest of any other crop.[23] Still, most citrus growers in California depend heavily on pesticides.

There are two reasons for continued dependence on pesticides. One is the lack of existence of effective biological control agents for some pests, and second is the fact that the biological control agents are prevented from being effective because they are

TABLE A.3-2

Estimated Annual Applications For

Synthetic Pesticide Alternatives.

Pesticide Applied For	Recommended Application (pounds a.i./acre) Different Pesticides	Estimated Petroleum Oil for Control (pounds/acre)	Percent Reduction for Applied Alternative
Key pests of orange, grapefruit			
California red scale	2.5 to 12.7		
California red mite	1.0 to 4.5		
Annual Total	3.5 to 17.2	202	98.3 to 91.3
Key pests of lemon			
California red scale	2.5 to 12.7		
California red mite	1.0 to 4.5		
Citrus bud mite	1.5 to 1.7		
Annual Total	5.0 to 18.9	202	98.0 to 90.6

susceptible to the pesticides being applied.[8,24] There are two important citrus pests for which there does not appear to be effective biological control: the citrus thrips and the citrus bud mite. Both of these may be to some extent attacked by predaceous mites.[9] The other key pests which are subject to control by petroleum oil, the California red scale and the red mites, are controlled by natural enemies either completely or substantially in those areas where chemical treatments have not reduced effective predators. In some parts of Southern California, citrus does not now require treatment for red scale since it is controlled primarily by _Aphytis_ parasites. In the San Joaquin Valley, control is much less substantial[24] for red scale though red mite usually is controlled by a virus. An estimated 10,000 acres in Ventura County do not require pesticide treatments because biological control is sufficient.[11]

As an alternative to petroleum oil treatment, the outlook for biological control in citrus is very promising, but there are some difficulties with regard to obtaining large reductions in oil use. First, nearly 60 percent of the reported oil used on citrus is applied to lemon trees. Much of this is for control of citrus bud mite for which there is no adequate biological control. Secondly, many orchards which have been sprayed for control of red scale and red mite have also had the population of natural enemies of those pests reduced so that it might take three or four years for a stable population of natural enemies to be established.[8] Thirdly, even where effective biological control has been established there can be occasional serious outbreaks of pests. The preferred method for changing from reliance on chemical control to reliance on biological control is through the use of a supervisory program such as Integrated Pest Management. The release of mass produced natural enemies into an orchard is one approach to the difficulties of withdrawal from pesticide use.[3]

A.3.1.1.7 Integrated Pest Management

Integrated pest management (IPM) of citrus crops has been practiced by independent pest management consultants in California since 1960.[25] In the San Joaquin Valley, the acreage under supervision of independent consultants had increased to 6 percent of the total citrus acreage by 1970.

Most independent pest consultants supply pest control advice for a fixed fee per acre. It is in their interest to control pests with a reduced use of pesticides in order to remain competative with advisors from chemical companies who practice conventional control.

Hall and his co-workers have carried out two in-depth surveys on the performance of independent pest management consultants to cotton and citrus growers in the San Joaquin Valley.[26,27] The results of the surveys showed that IPM reduced pesticide use by one-third to two-thirds, maintained yields at levels comparable to those obtained under conventional control and did not decrease growers' profits. The studies did not indicate what kind of pesticides were involved or if there was a shift to different pesticides under IPM.

Another program to develop IPM methods for citrus has been established by the University of California. Experiments are being carried out in the Central Valley, the intermediate coastal district and the interior at Woodcrest near Riverside. Only results for three years at the Woodcrest site have been released in some detail.[3]

The most satisfactory results at Wood crest were obtained with an IPM program. A basic part of this program was a N R 415 oil spray in September which was primarily for red mite control. Ten gallons of oil per acre (about 50% of usual) was applied with an air blast sprayer which gave an improved distribution of spray droplets averaging less than 150 microns median volume diameter. The botanical chemical Ryania was used as needed for thrips control. There were other treatments tested in the program including a conventional synthetic chemical spray regime.[3]

The average number of thrips scars and of red scales on fruits and leaves were about the same for the IPM and conventionally treated plots. Red mites were fewer in the IPM plot though control was adequate in both plots. The annual cost of pest control in the conventional treatment was $158 per acre and $54 per acre for the IPM.[3]

In this example an IPM program gave overall pest control generally equal to a conventional synthetic chemical program. If the IPM were compared with a conventional program using petroleum oil for scale and mite control, the reduction in organic chemical applied would be from 50 to 60 percent.

Another IPM program was tested which involved the use of synthetic pesticides but no oil. This program was less successful in maintaining low levels of some pests, particularly California red scale. However, in three years of tests, citrus yields were equal to those obtained with the conventional spray program or IPM with oil sprays.

The use of IPM for citrus as for other crops requires a close supervision of the levels of pest populations in order to avoid unacceptable risks.[24] Therefore, the extent to which the developed IPM programs can contribute to reduced pesticide use is dependent upon the extent to which the program can be implemented with adequately trained personnel.[4]

A.3.1.2 Pears

A.3.1.2.1 Introduction

Pear production in 1977 ranked 36th among California's crops in terms of market value. Approximately 303,500 metric tons (42.5 percent of the nation's harvest) were produced on 37,696 acres, making California the nation's chief source of pears. The value of the pear crop was approximately $45.1 million. The counties of Lake, Sacramento, Mendocino, Solano, and El Dorado lead the state in total acreage with 26,421 acres (66.4 percent of the state's total).[1,28] Table A.3-3 shows the 1977 distribution of pear acreage by county.

A.3.1.2.2 Oil Application Methods

Ground air blast sprayers are used extensively in California

TABLE A.3-3

1977 Pear Acreage in California by Counties[a]

(Counties over 1000 acres)

County	U.C. Davis P.U.R. Acreage	Percent of Total Pear Acreage
Lake	8,727	21.6
Sacramento	7,144	17.7
Mendocino	4,337	10.7
Solano	3,697	9.2
El Dorado	2,516	6.2
Yuba	1,802	4.5
Santa Clara	1,657	4.1
Sutter	1,571	3.9
Sonoma	1,105	2.7
All other counties	7,816	19.4
Total	40,372	100

a. Source: 1977 California Fruit and Nut Acreage pear production. Aerial applications are used when orchard conditions prevent entrance with conventional ground sprayers. It is estimated that 20 percent of the total pear acreage is treated by air.[15]

Recommendations for dilute sprays of dormant oils are 16-20 gallons of oil per acre.[29,30] Growers using these recommendations apply between 400 and 1,000 gallons of spray per acre. At the higher "drench" rates (800-1,000 gallons/acre) there is substantial runoff. Estimates are that less than 25 percent of the pear growers use such high volumes.[31]

Concentrate or low volume oil spray recommendations are 6-15 gallons per acre depending on oil type in less than 100 gallons of water. At concentrate spray rates, labor costs are less because of shorter, less frequent "downtimes" and less water used per acre while control effectiveness remains the same.[31] Speed of travel is more critical with concentrate spray rigs, and there is a small margin for error with this method.

A.3.1.2.3 Target Insects

Table A.3-4 lists the major pear pests from among the 30 which attach pears. Below are brief descriptions of these major pests.

<u>Codling Moth</u>. <u>Laspeyresia</u> <u>Pomonella</u>, (Linn) has long been the primary pest of pears around which all in-season spray programs revolve. Fruit injury by codling moth larvae can make the fruit unmarketable if "deep entry" occurs. Shallow entrys ("stings") damage may disqualify the fruit for the fresh market, but it may

TABLE A.3-4

Major Pests of California Pears[29,30,33,38]

Insect Pests

Codling moth, *Laspeyresia pomonella* L.
Growing season control programs key on this pest.

Pear psylla, *Psylla pyricola*
Extensive use of dormant oils controls this pest.

San Jose scale, *Quadraspidiotus pernicrosus*
Dormant oils used to control this pest.

Mites

European Red Mite, *Panonychus ulmi*.
Not serious in Lake County.

Secondary Outbreak Pests

Two-spotted mite, *Tetranychus urticae*

Pear rust mite, *Epitrimerus pyri*

Pear leaf blister mite, *Eriophyus pyri*

Aphids

3 species most commonly encountered
Green peach aphid, *Myzus persicae* (Sulzer)

Melon or cotton aphid, *Aphis gossypii* (Glover)

Bean aphid, *Aphis fabae* (Scopoli)

be acceptable to the cannery industry.[31,32]

Untreated orchards yield 40-60 percent fruit injury from codling moth larvae deep entry. Commercially acceptable control of codling moth maintains fruit injury below the one percent level. This degree of control requires closely monitored, well timed applications of synthetic pesticides. Gution® is the prefered compound because it is not as disruptive to beneficial species as other available products. Commercial growers use only synthetic chemicals to control codling moth, and all have been detrimental to predator species to some degree. Consequently, control measures for other pests are usually necessary.[33-36] Oil is most commonly used to offset the deleterious effects of these sprays.

Pear Psylla. Control of pear psylla, Psylla pyricola (Forster) is essential to commercial pear production. Psylla transmit the mycoplasm like organism responsible for pear decline disease.[33,37,38]; a disease which nearly destroyed the pear industry in the 1950's.[39] Besides transmitting pear decline, psylla can also cause severe defoliation and stunting of vegetative growth if infestations are large. Fruit quality is also lost when honeydew secretions by the larvae give rise to black fungal growth on fruit. Psylla are known to develop resistance to chemicals rapidly, and resistance to nearly all synthetic pesticides has been observed.[40,41,42]

San Jose Scale. Quadraspidiotur perniciosus (Comstock) is constant threat to pear tree vitality and fruit quality in

California. Because of the extremely small size at maturity (adult females are approximately 2 millimeters in diameter), this scale is often overlooked during orchard surviellance, and it can achieve pest status before it is noticed. Feeding scales extract plant juices from foliage and new branches thus depressing plant vigor and fruit development. Fruit injury is evidenced by red halos around the scale and sunken areas caused by feeding.[33,38]

European Red Mite. The European red mite *Panonychus ulmi* (Koch) attacks the foliage of pear trees and populations are known to develop rapidly to high levels if not controlled. Complete defoliation can occur from extremely high populations, and fruit development is reduced proportional to foliage destruction.[33,38]

Secondary Outbreak Pests. Three other species of mites, the twospotted mite, *Tetranychus urticae* (Koch), the pear rust mite, *Epitrimerus pyri* (Nalepas), and the pear blister mite, *Eriophyes pyri* (Pgst.) are pest problems usually because of codling moth spray programs.[33,38,43] The destruction of the natural predators of these species with synthetic chemicals used for codling moth control frees these species to rapidly develop large populations. Current dormant oil use is directed primarily at overwintering adults and eggs in an attempt to keep populations at low levels. Summer oils are combined with codling moth cover sprays to offset the adverse effects of these synthetic products. Rates are the same as those for psylla and scale.

Other Pests. Pear pests, against which oil is directed, not discussed above are normally maintained below the pest status levels by codling moth sprays, psylla, scale and mite programs and other cultural practices.[33]

A.3.1.2.4 Application Rates

Dormant oil application at 16-20 gallons per acre dilute and 10-12 gallons per acre concentrate are effective against pear psylla, San Jose and other scales, mites (European Red, Twospotted, Brown and Pacific) and mite eggs. The more highly refined supreme or superior oils are effective against the same pests but at rates of 1/3 to 1/2 that of the dormant oils. One or two cover sprays are normally applied between December and March first. If overwintering populations are low, only one cover spray is necessary.[31]

Foliar season oil applications are predominantly highly refined, light medium summer, supreme or superior oils. These are applied at 4 gallons per acre. Addition of synthetic chemicals to oil sprays usually increases the effectiveness of both. However, some compounds are incompatable with oils, and restrictions and manufacturer's specifications must be followed carefully. An average of three cover sprays per foliar season are applied although this number may vary each season and from orchard to orchard.

A.3.1.2.5 Advantages and Disadvantages

Oil use on pears during periods of water stress has resulted in foliar injury. Pesticidal action of oils decreases rapidly with time and offers little residual activity.[15]

While active killing power is of relatively short duration, delayed dormant applications of oil will delay ovipositioning by overwintering psylla adults by up to five weeks. This allows predator species more time to develop thus effecting a greater degree of control.[44]

As mentioned before, no resistance has been found when oil is used; whereas, psylla have shown resistance to almost all synthetic chemicals used against it. Mites and scale insects are also developing resistance to increasing members of synthetic products.[15,39]

Synthetic pesticides used alone against scale insects are not as effective as when used in combination with oils. The oil penetrates under the protective scale carrying the synthetic to the target. Synthetics alone are not able to penetrate as effectively.[31]

Nonsynthetic hydrocarbons allow predator species to develop virtually unhindered; whereas, synthetic organics are usually very disruptive to beneficial species.

Oils applied at dilute rates (16-20 gallons per acre) act on dormant trees to stimulate a more uniform bloom in pears. Pears require a chilling factor of approximately 1,200 hours below 45°F if maximum synchronized bloom is to occur. Uniform bloom is important to growers because the threat of fire blight disease inoculation increases with increasing duration of the bloom. Dormant oils act to suppliment the chill factor during warmer winters and are important tools to many growers in achieving desireable bloom patterns.[31]

A.3.1.2.6 Synthetic Pesticide Use

Introduction. Reported use of synthetic insecticides totaled 93,220.17 pounds in 1977. As seen in Table A.3-5 Guthion® (azinophosmethyl) was the dominant chemical used contributing 46.6 percent to the total usage. It must be stressed that the total reported use is only a small fraction of the actual use in the state, and that the pesticide use report is valuable in qualitatively evaluating the use pattern but inaccurate for quantitative estimations.[43]

Use Pattern. The majority of the synthetic pesticides used are for control of codling moth. Three compounds, Guthion® (azinophosmethyl), carbaryl (Sevin®), and Imidan® were responsible for 57.8 percent of the state total reported usage, all of which is directed primarily against codling moth.[2] Carbaryl and Imidan® are more disruptive to beneficial species than Guthion[R] and depress predator populations which control secondary outbreak pests such as mites and scales as well as pear psylla.

Three nonrestricted chemicals: Plictran (1,974.77 lbs.), Perthane (934.02 lbs.) and Diazinon (377.07 lbs.) accounted for 3.5 percent of this total.[2] It is believed that usage of these compounds is much higher than reported values, as these three compounds are recommended for use in all integrated pest management programs.[15,29,30] Synthetic insecticides are used almost exclusively from bud break through leaf drop and often in combination

TABLE A.3-5

1977 Synthetic Pesticide Use on Pears

Product	Pounds	Acreage	Percent Total Use (Pounds)	Target Pests *
Guthion ®	43,458.01	44,157.35	46.6	CM
Endosulfan	14,823.18	7,622.60	15.9	CS PBM PRM PP
Carbaryl	8,824.17	2,069.00	9.4	CM,SJS,PBM,PRM, LFRIR
Ethion	8,579.58	5,689.60	9.2	ERM,TSM,PRM, SJS
Parathion	7,806.85	4,764.00	8.3	PP,MB,S
Dithane	2,196.00	430.00	2.4	
Plictran ®	1,974.77	2,143.00	2.1	TSM,ERM
Imidan ®	1,673.00	642.00	1.8	CM
Lime-Sulfur	1,495.17	49.00	1.6	PEM,PRM,SJS
Perthane ®	934.02	229.00	1.0	PP
All other Compounds	1,455.42		1.7	
Total	93,220.17		100	

Source: California Pesticide Use Report 1977

*Key: CM -Codling moth; CS -Consperse Stink bug; PBM - Pear Blister Mite; PRM Pear Rust Mite; PP - Pear psylla; SJS - San Jose Scale; LFLRL - Leafroller; ERM - European Red Mite; TSM - Two-spotted Mite; MB - mealybugs; S - Scale with highly refined summer oils because of the synergistic effect attained. Very small amounts of synthetic pesticide are applied during the dormant season.

Synthetic Alternatives. Pydrin®, a relatively new synthetic pyrethroid on the market, holds promise as a possible dormant spray which could replace 100 percent of dormant oil applications. Its value is restricted to the dormant season because of the extremely disruptive impact on beneficial species. The long residual effect of Pydrin® makes it effective against immigrating pest populations after the initial spray. It does not exert a control on eggs of pest species. Use of Pydrin® is currently restricted to the dormant period under a section 8 use permit, and no applications may be made after the cracked bud stage. Research is currently under way at the University of California Extension Offices near Sacramento and in Mendocino County to determine in greater detail the effects of this compound on beneficial species. More information should be available before the close of this growing season.[31,45] Currently, no resistance has been noted but is expected.[46]

Perthane®, at recommended rates of 1-2 gallons per acre dilute or 1 gallon per acre concentrate, provides highly effective control of light to moderate pear psylla populations. To control very heavy populations, Perthane® must be combined with oils. Resistant strains of psylla are known to develop rapidly when Perthane® is used regularly without oils.[33]

This compound may be used successfully against the two-

two-spotted mite during the growing season and may be the preferred chemical if field conditions are very dusty and populations of European Red mite and rust mites are extremely low. Plictran is known to destroy predators of the European Red mite and rust mites and flareback populations of these pests are characteristic of Plictran® use.

This product may be substituted for supreme or superior oil applications to control the two-spotted mite during the growing season. However, because of its limited spectrum of control and disruption of beneficials, it must be used with caution.[33]

A.3.1.2.7 Biological Control

A partial list of biological control agents is contained in Table A.3-6. These agents exert varying degrees of control on different pests depending on populations of pests and predators, orchard environmental conditions and pesticide spray programs. In unsprayed orchards, biocontrol agents can keep psylla, mites and scale populations below economically damaging levels but are unable to control codling moth, the most serious pest of pears.[33]

A.3.1.2.8 IPM Programs

IPM practices have proven to be very effective for pear growers in reducing insect and mite problems and in reducint costs.[39,47] However, IPM as currently practiced by approximately

TABLE A.3-6

Biological Control Agents for Pests which
Receive Nonsynthetic Hydrocarbon Insecticides

Agent	Pest Controlled
Predacious Mites	
Typhlodromus accidentolis (Nesbitt)	• spider, rust, and leaf blister mites
Amplyseius hipisci (Chant)	• mites
Lacewings and Snakeflies	
Chrysopa carnea (Stephens) _Chrysopa nigricornis_ (Burm) _Raphidia_ spp.	• aphids, psylla (eggs and larvae), spider mites and eggs, mealy bugs, scale insects, mith larvae (limited), other soft bodied organisms
Lady Beetles (over 175 species)	
Hippodamia convergens (Guer.)	• aphids, mealybugs, scales, mites
Stethorus picipes (Casey)	• spider mites
True Bugs	
Order: Hemiptera (numerous species)	• aphids, mites, psylla (nymphs and eggs), thrips, scales, whiteflies, moth eggs
Predaceous Flies	
Syrphid fly larvae	• aphids and scale insects
True Spiders (numerous species)	• aphids, scale insects
Wasp Parasites (numerous species)	• aphids, scale insects, and psylla

20 percent of California's pear growers will not lead to the reduction of oil use in California. It may conceivably increase the amount of oil used by encouraging foliar season cover sprays to suppress pest populations without effecting predator populations.[46] "Suppression" is the best word to describe summer cover sprays for psylla, mites and scales as control is extremely difficult.[48]

Pear IPM programs stress the need for close monitoring of orchards and elimination of cover sprays where this can be cone safely.[32,33,34]

A.3.1.2.9 Other Alternatives

<u>Insect Growth Regulators</u>. Insect Growth Regulators (IGR) hold promise for future insect control. Hormones which restrict juvenile forms from maturing are now being tested and refined. The Zoecon Company is presently investigating different methods and materials. While not currently available, research should be encouraged in this area.[31,48]

<u>Granulosis Virus</u>. Because the codling moth is such a persistant pest and chemical controls are often disruptive to the predators of the mites and scales, control of the codling moth by non-chemical means would be extremely valuable in reducing oil sprays. A granulosis virus specific to codling moth has been isolated and is being developed for possible commercial use.[35]

One hundred percent control of codling moth by the second year was reported by Huber and Kickler in 1977 in apples.[50] Jaques, et al. (1977)[51] reported reducing deep entry damage by 55 to 96 percent compared to control trees. Shallow entry, however, was not reduced significantly because of the delay in action of the virus in killing the moth larvae.

Research should be encouraged in this area.

Sex Pheromone Traps. Some work has been done through the U.C. Extension Office to observe the effectiveness of trapping all male codling moths before they breed by using large numbers of sex pheromone traps per orchard. Moderate populations can be controlled to some degree but large populations are unaffected.[31]

Cultivation Practices. Weed control in pear orchards can indirectly influence pesticide use. By encouraging a healthy cover crop, potential pests are often kept out of trees and growth of predator species populations is also stimulated.[52,53]

A.3.1.3 Other Deciduous Fruit Trees

A.3.1.3.1 Introduction

Tree crops being considered here include almonds, apricots, nectarines, peaches, plums, and prunes. Major growing regions for these crops lie in the lower Sacramento Valley and the San Joaquin Valley. Production statistics for each crop are listed in Table A.3-7.

Pests and pest control programs for these crops are similar and therefore will be treated together. Fresh fruit markets demand high cosmetic quality in the fleshly tone fruits, and

TABLE 3-7

1977 Production Statistics for Selected Tree Crops

Crop	National Ranking	Californias Share of Production (percent)	Harvested Acreage ($X10^3$)	Production (metric tons) $X10^3$	Value (1,000 dollars)	Rank Amoung Californias Commodities
Almond	1	99.4	275.4	231.3	267,750	11
Apricots	1	97.0	27.5	129.7	28,428	42
Nectarines	1	98.2	14.0	136.1	30,450	41
Peaches	1	66.3	68.5	899.7	139,398	17
Plums	1	a	25.2	142.4	49.141	34
Prunes	1	a	70.7	142.4	76,930	27

a not available

Source: California Principal Crop and Livestock Commodities, 1977.

this necessitates careful control of pest insects which can damage fruit quality and appearance.

A.3.1.3.2 Pest Problems in Relation to Oil Usage

Most nonsynthetic hydrocarbons are applied to these tree crops during the dormant season from December through February. Applications are made to control populations of San Jose Scale and other scale insects, Eureopean Red, Twospotted and Pacific Mites, Peach Twig Borer, and various aphis species.[54] Descriptions of most of these pests can be found in Section

San Jose Scale, Quadraspidiotus perniciosus (Comstock) is one of the most serious pests which is controlled with dormant oil applications. Failure to spray one season may result in serious losses of fruit and fruiting potential due to the scales ability to kill major portions of fruiting and scaffolding limbs.[43] This is particularly true in peaches and plums. Although a serious pest, one dormant season application generally eliminates the need for in-season control measures using oils.

Navel Orange Worm _Paramyelois transitella_ (Walker) in almonds effect pest control programs in much the same way as codling moth does in pears. Approximately 80 percent of the fruit rejected is because of larval infestation of fruit by this pest.[55] Control of navel orange worm is accomplished with the synthetic pesticides carbaryl or Guthion®. Both of these are damaging to beneficial specie populations, thus mite and scale insects may be released from natural controls. Dormant season oil sprays are designed to depress mite and scale populations before leaves appear when control becomes much more difficult. As seen in the monthly distribution figures, this practice is very effective.

The peach twig borer, _Anarsia lineatella_ (Zeller) depresses tree vitality as adults attack and kill new growth by boring into the base of small twigs and branches and feeding on cambium tissue.[56] Fortified oils at 4-6 gallons per acre plus 2 pounds of parathion or diazinon during the dormant - delayed dormant season are recommended control treatments. After bud break, control is achieved with synthetic pesticides only.[57,58,59]

A.3.1.3.3 Application Rates and Methods

Applications of pesticides are predominately with ground sprayers, aerial sprays accounting for only 20 percent of the total volume of chemicals applied. Low volume spray applications are the most efficient methods available to the commercial grower. Dormant emulsive oils and dormant oil emulsions are sprayed at rates of 8 to 15 gallons per acre low volume, and at 12 to 20 gallons per acre high volume.[57-60]

High volume cover sprays are applied at rates approximately 20-25 percent higher than low volume sprays. While this method requires less accurate sprayer calibration and a more flexible speed of travel, waste losses are higher than with low volume sprays.

More highly refined narrow range oils are used at half the volume of the less refined dormant emulsive oils and dormant oil emulsions discussed above. Pest control is equivalent with these summer oils when used according to recommendations.

A.3.1.3.4 Synthetic Pesticides

Recommended synthetic pesticide use is limited to the foliar season when used alone or in combination with oils when applied during the dormant season. There are no dormant season recommendations which call for synthetic chemicals alons. Growers do not have available synthetics which can destroy mite eggs nor which control such a broac spectrum of pests as oils. Continued use of synthetics such as Kelthane® or ethion at recommended rates will cause resistance problems in mites. Use of Guthion® and carbaryl to control San Jose Scale on peaches and nectarines will also depress mite predator populations, and secondary flarebacks of mite pests may occur.[31,33]

A.3.1.3.5 Biological Control

There are numerous insect and mite species which function within the orchard environment to exert partial control over many pest species. Predators of scales, mites and aphids are listed in Section A.3.1.2 on pears. These predators exert control pressures on pest populations wherever pest species are found. Control of the navel orange worm by the predator Pentalitomastix plethuricus has not been achieved at economic levels. Good sanitation of almond orchards and supplimental cover sprays of synthetic pesticides are necessary for acceptable levels of control.[55] As with all crops, use of bio-control agents will reduce the pest populations, and subsequent reductions in cover sprays can be achieved; however, predator species alone have not been successful in keeping many key pests below economically damaging levels.[33,34]

A.3.1.3.6 Integrated Pest Management

Integrated pest management (IPM) in these six crops is only now beginning.[31,46] A program initiated in 1978 for almonds will require several years before success can be accurately measured. Many growers of other tree crops are using IPM principles to monitor pest density fluctuations in their orchards and are timing cover sprays to coincide with the most critical stages of pest development. The impact of IPM programs on nonsynthetic hydrocarbon consumption is not ascertainable at the present time.

A.3.1.3.7 Cultural Practices

Orchard sanitation is probably the most beneficial cultural practice growers can pursue in attempts to reduce pest populations. Culls and unharvested fruit left in the orchard are open invitation for increased pest problems the following year. Dropping culls from trees after or during the harvest and destroying them with irrigation water or disking techniques can effectively eliminate potential inoculum.[61,62]

A.3.1.4 Alfalfa

A.3.1.4.1 Introduction

California hay production ranked as the number 5 crop in the state and ranked number 3 in the nation during 1977.[28] Alfalfa hay made up 68 percent (1,140,000 acres harvested) of the state's total hay production in 1977 and had a production value of over 433 million dollars.[63] Alfalfa is an especially good cash flow crop because of the numerous cuttings that are made each year.

A.3.1.4.2 Synthetic Pesticides

Introduction. There are several synthetic herbicides registered for use on alfalfa in California that could reduce most if not all of the use of F-10 oils for weed control and seed desiccation. The 1977 PUR data show that over 590,000 pounds of synthetic herbicide were used separately or in conjunction with F-10 oils on alfalfa grown in California. Of this amount, only 9 percent of the synthetic herbicides reported were restricted and had to be reported; therefore, as was the case of reported oil use, only a fraction of the total actually used is represented in the PUR.

Synthetic Herbicides. Due to the fact that 98 percent of the reported F-10 oil use on alfalfa was for winter weed control, only synthetic alternatives for winter weed control will be discussed in any detail.

Diuron at 1.2-2.4 lb. ai/A has been effective for the control of annual weeds in dormant alfalfa.[64] Rainfall or irrigation is essential to move the herbicide into the soil where the weed seeds germinate. Diuron should only be used in established alfalfa stands that are one year old or older and should be applied during December or January due to injury which could occur to some varieties of alfalfa if it is applied later than January. The fact that common groundsel is not controlled by diuron limits its use to areas where groundsel is not a problem. Small quantities of diuron may remain in the soil beyond the harvest of the crop; therefore, it should not be used during the last year of the stand especially if crops susceptible to diuron such as sugar beets, cereals or lettuce are to be planted following the alfalfa crop.[65]

DNBP is an oil soluble herbicide that is usually mixed with 30 gallons of weed oil and 30 gallons of water. However, DNBP is also available in an emulsifiable form when it is formulated as 30 percent ai with 70 percent inert ingredients which includes 30 percent weed oil. The recommended application rates call for 1.25-1.9 lbs. of active ingredients per acre emulsifiable DNBP with 40-60 gallons of water per acre for satisfactory control of winter annual weeds when applied to established stands during the dormant season.[66] This treatment may give satisfactory control of broadleaf weeds but probably would not give satisfactory control of grassy weeds. For improved residual control of most annual weeds, it is recommended to use 4-12 pints of emulsifiable DNBP mixed with diuron plus 5-10 gallons of weed oil and enough water to make 50-100 gallons of total spray per acre and applied to the alfalfa when it is dormant.[67]

A reduction greater than 99 percent of the amount of weed oil used on each acre of alfalfa treated would be realized if the emulsifiable DNBP formulation were used with only water, and a 66 to 83 percent reduction would be attained by using the DNBP, diuron, weed oil combination assuming the present average application rate for oil alone is 30 gallons per acre.

Paraquat is a contact herbicide for use in dormant alfalfa for winter weed control. Paraquat at 0.5 to 0.75 lbs. ai/acre can be applied to established stands after the last fall cutting when the crop is dormant and before spring growth starts. It should be applied when broadleaf weeds and grasses are succulent and 1 to 6 inches tall.[64]

Paraquat is an effective weed control herbicide.[68] It has the advantage over weed oil of being readily applied by air when the fields are too wet to get in ground spraying equipment which is necessary for effective coverage with weed oil. However, some disadvantages of paraquat are that it is a restricted herbicide due to high toxicity to humans and requires a use permit from the agricultural commission, and there is a spray drift hazard to susceptible crops when it is applied by air. Additionally, paraquat has the restriction that it cannot be applied to alfalfa if there is more than 2 inches of alfalfa regrowth due to high residue problems, and this point alone can limit the number of situations where paraquat can be used.

A spray of CIPC (2-4 lbs. ai/acre) plus DNBP is very effective in controlling winter weeds in alfalfa.[68] Metribuzin at 0.25 to 1 lb. ai/acre applied as a broadcast spray is also very effective for controlling winter weeds in established alfalfa.

North of Interstate 80 in California, terbacil at .4 to 1.2 lbs. ai/acre applied as a broadcast spray can be used for control of winter weeds. A single application can be made in the fall after plants become dormant or in the spring before new growth starts. For semidormant and nondormant varieties, the application can be made in the fall or winter after the last cutting.[64,68]

Table A.3-8 shows winter annual weed susceptibility to the herbicides discussed for use on alfalfa when applied at the suggested rates. Synthetic herbicides are economical and efficient alternatives to using herbicidal oils for winter weed control in alfalfa. However, it should be mentioned that replacement of weed oils with synthetics or reduction of oil use below 30 gallons per acre would result in the loss of weevil suppression afforded by the oil. Growers that depend on weed oil weevil suppression would have to add some other weevil suppression program to their overall management plan, thus increasing use of synthetic insecticides.

Synthetic Desiccants. Some synthetic materials sprayed on hay for desiccation can be a problem with seed germination. Synthetics work fast and sometimes don't give good coverage on a heavy stand of hay. On a heavy stand of hay, a common practice is to make a first spray with emulsifiable DNBP and then to make a second spraying with DNBP and weed oil.[69]

Endothall at 0.33 to 0.75 lbs. ai/acre can be applied 5-10 days before harvest.[71] Emulsifiable DNBP at 1.25 to 1.9 lbs. ai/acre mixed with 10 to 20 gallons of water per acre can be applied 3 to 6 days before harvest.[66] Even DNBP at 1.25 to 1.9 lbs. ai/acre mixed with 15 gallons of weed oil per acre[64] could result in a reduction of up to 66 percent of the amount of weed oil used for desiccation of alfalfa if the manufacturer's recommendation of up to 45 gallons of oil per acre is assumed to be the maximum application rate.

TABLE A.3-8 Weed Susceptibility at Rates Suggested For Use in Established Alfalfa[68,70]

	Weed Oil + DNBP	Emulsifiable DNBP	Emulsibiable DNBP + Diuron	Diuron	CIPC	Metribuzin	Paraquat	Terbacil
Mustard	C	C	C	C	N	C	C	C
Wild Radish	C	C	C	C	N	C	C	C
Chickweed	C	C	C	C	C	C	C	C
Common Groundsel	C	C	C	N	N	P	C	C
Sheperdspurse	C	C	C	C	N	C	C	C
Fiddleneck	C	C	C	C	N	C	C	C
Dodder	C	P	C	N	C	N	-	-
Yellow Starthistle	C	C	C	C	-	-	-	-
Annual Bluegrass	C	P	C	C	C	C	C	C
Foxtail Barley	P	P	P	P	C	P	C	C
Wild Oats	P	P	P	P	C	C	C	C

C = Controlled

P = Partially Controlled

N = Not Controlled

Paraquat is also registered for preharvest desiccation of alfalfa seed but is not widely used.

A.3.1.4.3 Other Alternatives

Introduction. There are several alternatives to using herbicides for weed control in alfalfa that primarily work toward increasing the vigor of the alfalfa and decreasing the competition of weeds. Vigorous alfalfa is one of the best ways to control weeds, especially summer weeds. Summer weed control was not discussed under synthetic alternatives because weed oil is not used for controlling summer weeds with the possible exception of it being used to spot treat for dodder.

Cultural. Fields that are infested with perennial and annual weeds that are difficult to control should be avoided if possible and not planted with alfalfa.

Good land preparation is essential to obtain rapid stand establishment and to facilitate later cultural operations. Also, good land preparation can increase the effectiveness of pre-plant, pre-emergence and post-emergence use of selective herbicides.

Preplant irrigation to germinate weed seeds followed by light disking is an effective preplanting weed control technique. After the land has been prepared, planting the best variety for a particular locality is one of the most important ways of assuring good stand vigor and increased ability to outcompete weeds.

Proper management is essential for keeping a stand of alfalfa healthy. The proper timing of irrigation resupply to the soil alleviates the problem of plants being drought stunted or flooded when a set irrigation schedule is followed.

One of the more drought susceptible times for alfalfa is the regrowth after cutting; therefore, irrigation scheduling must allow for adequate water to be left in the soil to provide for rapid regrowth. However, the soil must be dry enough for equipment movement during cutting. It is also undesirable to irrigate directly after cutting to avoid germination of grasses and weeds which require light and a moist soil surface to trigger growth.[72] Additionally, excessive irrigation should be avoided as it can be responsible for outbreaks of phytophthora root rot and other diseases that will result in stand losses and reduced vigor.

A method which may be used by the individual producers to effectively manage irrigation water incorporates the use of water evaporation from an open pan as a measure of the crop water use. This method simply budgets the input, irrigation water and precipitation, and the output water use by the crop. However, this method requires a knowledge of soil, crop and weather data.[72]

Wheel traffic from harvesting alfalfa grown in sandy and medium textured soils can cause inhibited root growth to a depth of at least 14 to 18 inches as a result of soil compaction. Therefore, to maintain good alfalfa vigor necessary for weed competition, alfalfa grown in sandy and sandy loam soils should not be harvested as a first cutting until the alfalfa tap root is down at least 14 inches.[73] Additionally, experiments indicate that wheel traffic in alfalfa fields after harvest result in reduced yield and stand longevity, and as a result, increased competition by weeds is likely to occur.[74] The primary reduction in alfalfa vigor results from damage to crowns and regrowth shoots which can then be further damaged by development of disease.

Possible ways of reducing traffic effects and, thereby, increasing alfalfa vigor and stand longevity include standardizing wheel traffic patterns, establishing designated traffic lanes in the alfalfa field, corrugation or drill planting, and bed plantings with shallow furrows to be used as lanes for standardized wheel traffic.

Good insect pest management is very important in increasing alfalfa vigor, thereby enabling the alfalfa to out-compete weeds. Insect pest management will not be discussed in any detail here as it is indirectly related to the reduction in the use of weed oils for winter weed control. However, it is important to mention that there have been several insect control programs developed by ongoing research and are available to alfalfa growers. These include, but are not limited to, insecticidal, biological, cultural and integrated pest management (IPM) which uses a combination of the first three controls. Whatever insect control is used in alfalfa, it should be used judiciously as it has been estimated that nearly 1,000 species of arthropods occur in irrigated alfalfa in California but less than six of these affect crop yields significantly and many are beneficial predator insects in alfalfa and other crops.[75]

Clean farming where undesireable vegetation (mostly weeds) is removed from around the borders of a field has both positive and negative impacts. On the positive side, it eliminates the weed seed reservoir that can exist and perpetuate weed control problems. On the negative side, it could mean the loss of a reservoir for beneficial insects if the alfalfa field is not border harvested. By border harvesting, a 5-foot wide strip of hay is left along every other levee on the opposite side at each cutting. This means leaving less than 5 percent of the field uncut at any given harvest which provides habitat for beneficial insects. The extra growth is then picked up at the next cutting.[75]

Cutting frequency affects alfalfa vigor and weediness. Too frequent of a cutting cycle does not allow the roots to replenish expended carbohydrates used in the previous growth cycle; consequently, plants become less vigorous, have smaller crowns with fewer stems and eventually stands become thinner which immediately brings on an increased quantity of weeds. Alfalfa has the capacity to compete well with weeds, but it must be cut at intervals that allow it to maintain its vigor and rapidity of recovery where it can effectively shade out most competitive weeds. Experiments show that harvests made on 21 and 25 day intervals contained about 50 percent weeds while harvests at a 29-day interval (10 percent bloom) contained only 3 percent weeds, and harvest at 33(mid-bloom) and 37-day intervals were completely free of weeds.[76]

Fall and winter grazing of livestock in alfalfa fields (sometimes called sheeping off) can be used for controlling winter weeds, but it should only be done for short periods at lengthy intervals.[75] Some disadvantages to this practice include weed seeds being brought into the field by the livestock and damage to the alfalfa crowns.

<u>Mechanical</u>. Mowing and mechanical renovation such as harrowing of alfalfa fields are methods of controlling weeds, but both mean more wheel traffic in the field resulting in the negative effects previously mentioned concerning wheel traffic. An additional negative impact from mechanical renovation is the damage that can occur to alfalfa crowns and the increased susceptibility to secondary damage from disease. Cultivation is not desirable in solid plantings of alfalfa.

<u>Flaming</u>. Flaming alfalfa during the dormant season can give excellent winter weed and weevil control.[77] However, flaming is not practical to any extent in California for several reasons:[68]

(1) It is expensive by requiring 30-40 gallons of propane or diesel fuel per acre;

(2) The flamer must move slowly to be effective, and flaming can only be done profitably after the dew is evaporated, further limiting its feasability;

(3) Flaming can only be done legally on burn days, requires a burn permit, and the payment of a burn fee is required in Imperial and Sacramento Counties;

(4) Flaming is done most efficiently when the air is calm which further restricts its use.

Desiccation. Alfalfa seed is usually harvested by spray curing with a desiccant followed by direct combining or by windrowing followed by combining. The method that is used will be influenced by factors including local weather conditions such as the occurrance of strong winds, rain or dewless nights; grower preference; maturity of stand and amount of green seed; economy of operation; and the length of the harvesting season.[78] An advantage of windrowing rather than spray curing is that nearly mature seed will finish developing in the windrow after swathing. A negative aspect of windrowing is that there can be an increased loss of seed due to shattering.

A.3.1.4.4 Application Methods of Herbicides and Desiccants

Nonsynthetic Hydrocarbons. Winter weed control in alfalfa can be a real problem at times when weed oil is to be used, and the ground is saturated from rains. Germination of winter annuals usually dictates when weed control is needed, and as was mentioned previously, weeds are easier to kill when they are young; therefore, there is a necessity to get into the wet fields if at all possible.

Applying 30 gallons of weed oil with 30 gallons of water (the average and minimum effective rate) means applying a minimum of 60 gallons of spray per acre. This high volume spraying requires high pressure (50 to 60 psi) and high volume spray equipment.

Weed oils are seldom applied by air to alfalfa because sufficient coverage is difficult to achieve and effective weed control is not attained.

Alfalfa seed desiccation with weed oil is seldom done by air for the same reasons it is not used for weed control -- insufficient coverage. When there is a stand with heavy growth, two applications of fortified weed oil are usually applied by ground spray rigs. The second application will follow the first by several days and be applied in the opposite direction.

Synthetic Herbicides. Winter weed control with alternative synthetic herbicides is more efficient than using weed oils. Synthetics are usually applied as low volume sprays at low pressures (30 psi). This means a high capacity spray rig used for weed oil could spray for longer periods using synthetics without having to be serviced as frequently.

Synthetic herbicides can be applied very effectively by air which can mean proper timing of winter weed control regardless of field conditions. Air application also eliminates the soil compaction and crown damage that occurs when ground spray rigs are used whether they are equipped with flotation tires or not.

Aerial application of synthetic desiccants could be used effectively on alfalfa seed crops; however, PUR data indicate that at most only 1 percent was desiccated by air in 1977. Aerial application could reduce the extent of damage that occurs to mature seed pods by ground spray rigs.

The major drawback for using aerial applied herbicides is the problem of spray drift. The herbicides used for weed control and desiccation are very phytotoxic and can do serious damage to non-target crops hit by spray drift. This factor also needs to be considered when evaluating the type of spraying program that will be used.

A.3.2 Home and Garden Use

An on-site store survey for home and garden pesticide products in Sacramento, was made in December. The surveyed stores include:

Baker's Nursery	Fair Oaks Nursery	Gemco
Capital Nursery	Fountain Square Nursery	Handyman
Emigh Hardware	Four Seasons Nursery	House of White Garden Supplies
K-Mart	Orchard Supply of Sacramento	Savings Center
Lumberjack	Pay Less	Simms Hardware
Martins Hardware	Pay 'N' Save	Valley Hardware
Newberts Hardwate	Raley's	Ward's Department Stores

These stores (and all branches) total 53. This is approximately 58 percent of the total number of retail outlets for home and garden pesticides. A quick survey of the Telephone Directory revealed approximately 91 hardware and retail drug stores, nurseries and garden shops.

There were a total of 98 products surveyed. Of these products, only three were Formulation 10 in nature: Volck Supreme Oil Spray, Weed and Grass Killer and Mole and Gopher Get. The remaining products were all synthetic pesticides containing various percentages of nonsynthetics.

Due to the large number of retail stores selling pesticide products for home and garden use, a statewide survey in order to provide a quantitative estimation of the total consumption in California is beyond the capability and purview of this project. A more detailed survey effort under separate funding support is required to accomplish such an effort. For the purpose of this report, the home and garden use of oil pesticides in California was estimated based on the reported use statistics of the PUR. Such estimations were presented in Volume II of this report.

Table A.3-9 summarizes the results of the home and garden product survey in Sacramento.

A.3.3 Other Non-Agricultural Use

A.3.3.1 School Districts

A.3.3.1.1 Introduction

Available, published data showed only 178,068 pounds of NSHC's were applied by school districts in 1977.[79] Only oils applied by commercial pest control operators were required to be reported and, therefore, the PUR represents a small fraction of actual oil applications. Because of the deficiency of records, other data was secured by means of a telephone survey of selected school districts. Sixty-four districts were chosen at random, using a table of random numbers and an SR-51 calculator. These were contacted and the data from this survey forms the basis for the statewide use pattern and emissions inventory. The

TABLE A.3-9

Sacramento Home and Garden Pesticides Market Survey

CHEMICAL COMPOSITION

NONSYNTHETIC (%)

MANUFACTURER --- PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
Ortho Division																	
Diazinon	25.0	57.0															18.0
Dibrom	1.0			96.0													3.0
Flykiller D	36.0	49.0															15.0
Fruit & Vegetable Insect Control	25.0	57.0															18.0
Home Pest Control	0.81			99.12													0.07
Hornet & Wasp Jet Spray	1.13								83.87								15.0
Indoor Plant Insect Spray	0.53			0.08													99.39
Isotox	12.0	18.0															70.0
Isotox Lindane Spray #200	20.0	59.0															21.0
Lawn Insect Spray	5.3	3.0		87.0													4.7
Lindane	20.0	59.0															21.0
Malathion 50	50.0	33.0															17.0
Outdoor Insect Fogger	1.28	0.32		7.0													91.4
Volck Supreme Oil Spray				98.0													2.0
Chacon Chemical Corporation																	
Ant, Spider & Roach Spray	0.82			69.18													30.0

TABLE A.3-9 (cont'd)

MANUFACTURER --- PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
Chacon Chemical Corporation																	
Bordoil	6.4					30.0											63.6
Chlordane 73	73.0			22.0													5.0
Du-o-cide	31.65					67.1											1.25
House & Garden Insect Spray	1.45			8.05													90.5
House Plant Insect Spray	0.128			0.224													99.648
50% Malathion	50.0	40.37															9.63
Scale & Spider Mite Control	6.5					81.5											12.0
Systemic Spray	11.56	29.37															59.07
Weed-O-Kill	9.84	84.16															6.0
Miller Products																	
Chlordane 8E	72.3			21.5													6.2
Control	9.49				3.81						78.45						8.25
Diazinon	16.75	75.5															7.75
Fruit & Berry Spray	31.1	57.62															11.28
Garden Malathion	57.0	33.0															10.0
Home Patio Insect Killer	0.5				3.0												96.5
Lawn & Shrub Insect Spray	6.79	42.48		41.48													9.25
Noxall Vegetation Killer Concentrate	4.6	76.4															19.0

TABLE A.3-9 (cont'd)

MANUFACTURER PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
Spra-Oil						98.3											2.0
Systemic Yard & Garden Insect Spray	24.0										36.4						39.6
Tetradane Ornamental & Rose Spray	22.5	62.8															14.7
Vegetable & Fruit Spray	9.15										49.35			36.6			4.9
Wasp, Hornet, Ant and Roach Spray	0.5			64.46													35.04
<u>Velsicol Chemical Corporation</u>																	
Chlordane 4 EC																	
<u>Cooke Laboratory Products, Inc.</u>																	
Act-Plus Lawn Insect Spray	4.95	36.19					28.13										30.73
Double Duty Systemic Garden Spray	11.87						1.48										86.65
Fly-No	0.95					47.55											51.50
Fruit Tree Spray	39.24	12.0					15.0										32.96
Kop-R-Oil	27.9					22.0		7.0					1.2				41.9
Red Spider & Mite Spray	18.5										73.0						8.5
Roto-Lind	32.52	12.33					38.79										16.36
Sulf-R-Oil	6.0					70.0											24.0

TABLE A.3-9 (cont'd)

MANUFACTURER --- PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
49er Gold Strike																	
Chlordane 50	50.0			45.15													4.85
Diazinon 25	25.0	57.0															18.0
Dormant Spray	24.0					30.0							2.0				44.0
Malathion 5C	50.0										45.0						5.0
Rose & Plant Spray	1.545			0.115													98.34
Dexol Industries																	
Chlordane	73.0			22.0													5.0
Contact Weed Killer		80.0								5.0							15.0
Super Killer of Scales and White flys			68.7														31.3
Tender Leaf	0.043														0.07		99.237
Vegetable Garden Insect Spray	0.22			0.08													99.70
d-con Company, Inc.																	
Ant & Roach Double Action Jet Stream	2.15			94.84													3.0
Four/Gone	3.17			11.83													85.0
House & Garden Bug Killer	1.45			8.05													90.5
Professional Formula Ant & Roach Killer	1.9			95.1													3.0

TABLE A.3-9 (cont'd)

MANUFACTURER --- PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
Science Products Company, Inc.																	
Garden Insect Spray	25.0										69.0						6.0
Kelthane EC	18.5										73.0						8.5
Methoxychlor	25.0										72.0						3.0
Systemic Spray	11.9	49.6															38.5
Thuricide					3.0												95.2
Zectran Spray	12.8	17.3			42.5												27.4
Ciba-Geigy																	
Diazinon AG 500	48.0										36.0						16.0
Spectracide Ant & Roach Control	0.813			68.617													30.57
Spectracide Lawn & Garden Insect Control	25.0	54.4															20.6
Black Leaf Products Company																	
Black Leaf 40 Garden Spray															40.0		60.0
Cygone 2E	23.4										38.4						38.2
Malathion 50	50.0										42.0						8.0
Roach & Ant Killer	0.816			84.7													14.434
Rose & Flower Bomb	1.305			0.06													98.635
Wasp & Hornet Killer	1.13			51.87													47.0

TABLE A.3-9 (cont'd)

MANUFACTURER --- PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
Occidental Chemical Corp.																	
Diazinon Insect Spray	25.0	57.0															18.0
Lawn & Soil Insect Spray	6.7										83.0						10.3
Oil Spray						98.0											2.0
Weed & Grass Killer					100.												
Shell Oil Co.																	
Ciovap Insecticide	1.25				98.51												0.18
Outdoor fogger	4.1			6.0													89.9
Vaponite 2	24.9				75.1												
Destruxol Corp. LTD																	
Calsul Dormant Spray	1.9		67.0										0.9				30.2
Dubl-Deth	38.0										55.0						7.0
Hartz Mountain Corporation																	
Bye Bye Fogger	3.18			11.82													85.0
ALCO Chemical Corporation																	
DDVP 1 Spray	13.01	80.46															6.53
Fly Fighter Insect Spray	0.5			52.0													47.5

TABLE A.3-9 (cont'd)

MANUFACTURER --- PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
S.C. Johnson & Son, Inc.																	
Raid Yard Guard	1.725	0.1															98.615
House & Garden Bug Killer (formula II)	0.825			6.5													92.838
Boyle-Midway, Inc.																	
Black Flag Insect Spray	1.75			98.25													
Triple Action Bug Killer	1.8			4.2													94.0
Los Angeles Chemical Co.																	
Isocarb 100	1.0			83.8													15.2
Swift Agricultural Chemical Co.																	
Weed & Grass Killer	5.28											91.22					3.5
Knapp Chemical Co.																	
Roach Control	5.1			4.9													90.0
Chas H. Lilly Co.																	
Wasp & Hornet Killer	0.813			98.608													0.579
Michel & Pelton Co.																	
Whale Oil Soap																25.0	75.0

TABLE A.3-9 (cont'd)

MANUFACTURER --- PRODUCT NAME	Synthetic (%)	Aromatic Petroleum Solvents	Mineral Oil	Petroleum Distillates	Petroleum Hydrocarbon	Petroleum Oil unclassif.	Aliphatic Petroleum Solvent	Petroleum Sulfonates	Isoparaffinic Hydrocarbons	Paraffinic and Naphthenic Hydrocarbon	Xylene	Xylene Range Aromatic Solvent	Pine Oil	Vegetable Oil	Nicotine	Soap	Inert Ingredient
TUCO, Div. of Upjohn Co.																	
Endide	15.4																84.6
Mole & Gopher Get Mfg. Co.																	
Mole & Gopher Get										99.98							0.02
James Chemical Company																	
KXL	55.5													35.25			9.25

subsample represents 5.8 percent of the districts in the state. Results of the survey are discussed below.

A.3.3.1.2 Oil Use

A.3.3.1.2.1 Insecticides

Insecticidal oil applications reported in the PUR totaled 44,152 pounds in 1977, 63.7 percent of which were applied in Los Angeles County and 27 percent in Santa Barbara County. The telephone survey revealed no new data on insecticidal oils used by school districts and therefore, PUR values will be considered to be 100 percent of the actual. Oils used for this purpose were only 1.3 percent of all oils applied by school districts.

A.3.3.1.2.2 Herbicides

Extrapolation of telephone survey response indicated that 3,405,527 pounds of NSHC's were used as herbicides. Weed oils were 67 percent of the total and the remaining 32 percent were diesel and miscellaneous oils. (See Table A.3-10). Since the survey was random for the entire state, county by county distribution of survey data was based on the total number of schools in each county except where specific information was available.[80] In such cases actual values were used. A monthly distribution of oils applied could not be accurately determined through the phone survey. However, response indicated that applications occur seasonally, with spring and late summer being the two peak times. This information concurs with reported values (PUR) and therefore, monthly distributions were in accordance with the PUR pattern (see Figure A.3-1).

TABLE A.3-10

Summary of School District Survey and Statewide Extrapolation of Data

Insecticides	Survey Response Data (Total from 64 shools contacted) gallons applied	density lbs/gal	pounds applied	Statewide Total (pounds)	Percent of Total Oils
From PUR	-	-	-	44,152	1.3
Herbicides					
diesel & misc. oil	10,101	6.3	63,636	1,103,687	31.9
weed oil	17,030	7.8	132,834	2,303,840	66.7
Subtotal	27,131	-	196,470	3,407,527	98.7
Total Oil Applied	31,091	-	221,418	3,451,679	100

Of the districts contacted, 40 percent indicated no weed oils or diesel fuels were used for weed control. However, fifty-four percent of these were small, one-school districts where any weed control was by hand and/or mechanical methods. The remaining 46 percent used synthetic chemicals and mechanical methods of weed control. These are discussed in the following pages.

Advantages and Disadvantages. Nonsynthetic hydrocarbons have been used extensively in the past to control nonspecific

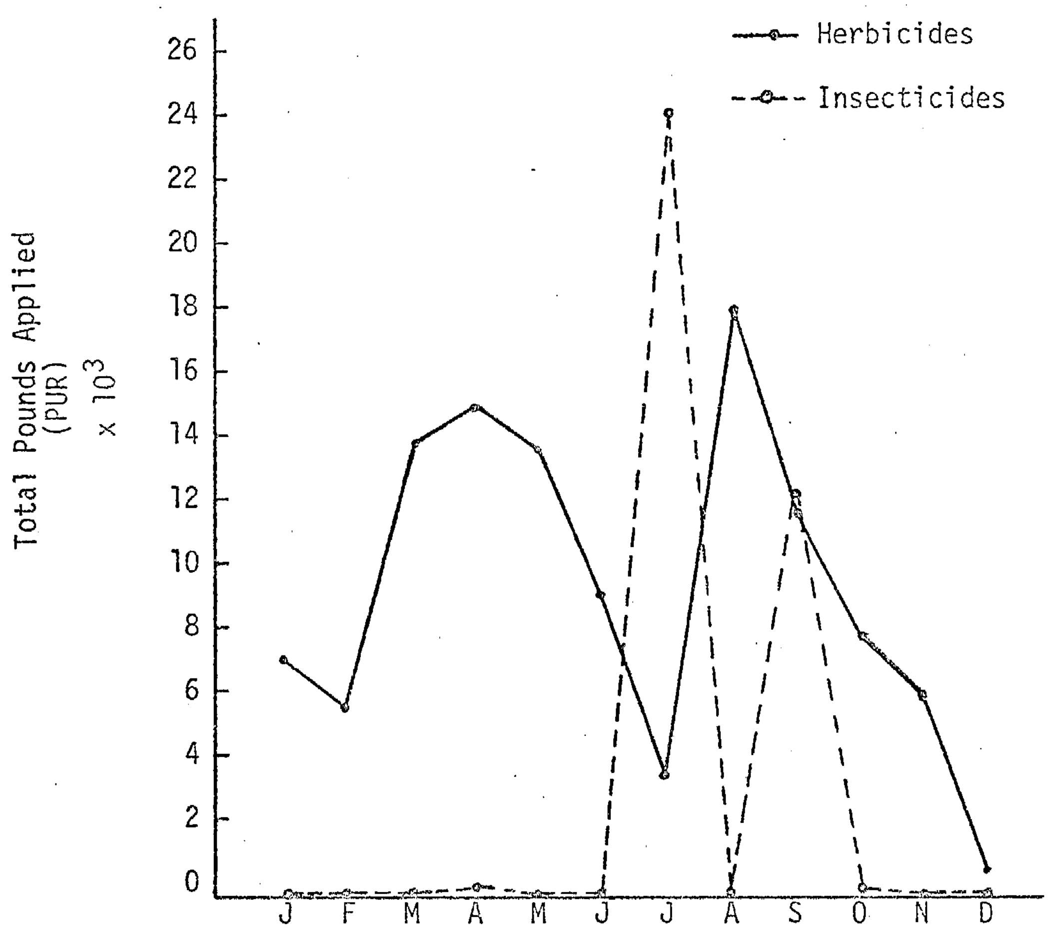

Figure A.3-1. Monthly Distribution of Oil Pesticides Applied by School Districts in 1977 (PUR).

weeds along fencelines, and property boundaries, and to control grasses around sprinklers, buildings and backstops. Oils are also used to burn in lines on athletic fields. Used for these purposes, oils are fast-acting, efficient top burners and have a relatively slight health impact on humans.[81]

All districts surveyed indicated that problems with oils are primarily asthetic. Offensive odors and stains on buildings and sidewalks were two of the most common complaints leveed against its use. More recently, price increases on all oil products have precluded their use for many districts and forced changes to synthetic chemicals and other methods of control.[82]

Synthetics. Use of synthetic pesticides on school grounds is very limited because of the potential health impacts of "hard chemicals" on humans. There are, however, two chemicals currently receiving widespread use; Round-up® and Phytar 560. Twenty-six percent of the districts surveyed are using either one or both of these products. These are slower acting herbicides, requireing several days for full effectiveness and some chemicals, such as Round-up® require special storage containers.[83] Other products being applied in small quantities include Assault, Dowpon-C, aminotriazole, simazine and diquat. White acrylic laytex paint is being used with good results in one district for athletic field boundaries and other districts appear to be interested in this approach.[84,85]

Conclusion/Recommendations. There are available at the present time synthetic chemicals which can satisfactorily control weeds and maintain athletic field boundaries as required by school districts. These include Round-up®, Phytar 560 and acrylic latex paints. Implementation can be facilitated through the education of school maintenance personnel as to the synthetic pesticides and alternative control methods available for their use. In light of Proposition 13 budget cuts and increasing oil cost, the use of weed oils and diesel fuel wil continue to diminish and the contribution of school districts to the total oil use may soon be insignificant.

A.3.3.2 Vector Control

A.3.3.2.1 Introduction

The data base for nonsynthetic hydrocarbon use by vector control is the 1978 Year Book of the California Mosquito and Vector Control Association Inc. (C.M.V.C.A.)[86] Data from this source represents 98 percent of total NSHC applications made by Vector Control in 1977. The Pesticide Use Report, while being fairly accurate in showing monthly distribution of oil applications, reflects only 12.5 percent of the oils actually applied.[87] The large discrepancy in the records exists for several reasons. Applications listed for Vector Control are those made by Vector Control personnel only and do not include contract works done for the agency. Another factor involves the application of industrial oils (i.e. diesel). D.F.A. records only registered pesticide applications and, therefore, approximately 1.4 million pounds of diesel oil (32 percent) remained unreported in 1977.[88] In conjunction with this there are other unresolved reporting procedure differences which add to the discrepancy. An additional five percent may be lost during processing because of mislabeling and related human error.[89]

A.3.3.2.2 Oil Use

Insecticides. Nonsynthetic hydrocarbons applied for insecticidal purposes accounted for 92 percent of the 4,466,788 pounds used by Vector Control. Larvicidal oils, such as Flit MLD and those of the Golden Bear Series, accounted for 58 percent of the applications and diesel fuels totaled 32.3 percent. The remaining

9.7 percent were weed oils and other miscellaneous oils (see Table A.3-11). Monthly distribution of NSHC's applied in California by vector control is shown in Figure A.3-2.

Oils have always been one of the most effective and widely used larvicides applied in California. Applied to water, oils block the air exchange mechanism of the aquatic larvae of the air-water interface producing death by suffocation. Since the action of oil is strictly physical, no resistance has been developed to oils and they remain an indispensible tool in abatement programs throughout the state.

TABLE A.3-11

Summary of Nonsynthetic Hydrocarbon Applications by Vector Control in 1977

	Oil Type	Pounds Applied	Percent of Oil Type	Percent of Total
Insecticides	Larvididal	2,381,718	58.0	53.3
	Weed Oil	396,988	9.6	8.9
	Diesel	1,325,478	32.3	29.7
	Miscellaneous	3,298	0.1	0.1
Subtotal		4,107,482	100	92.0
Herbicides	Weed Oil	275,179	76.6	6.2
	Diesel	84.127	23.4	2.0
Subtotal		359,306	100	8.2
GRAND TOTAL		4,466,788		100%

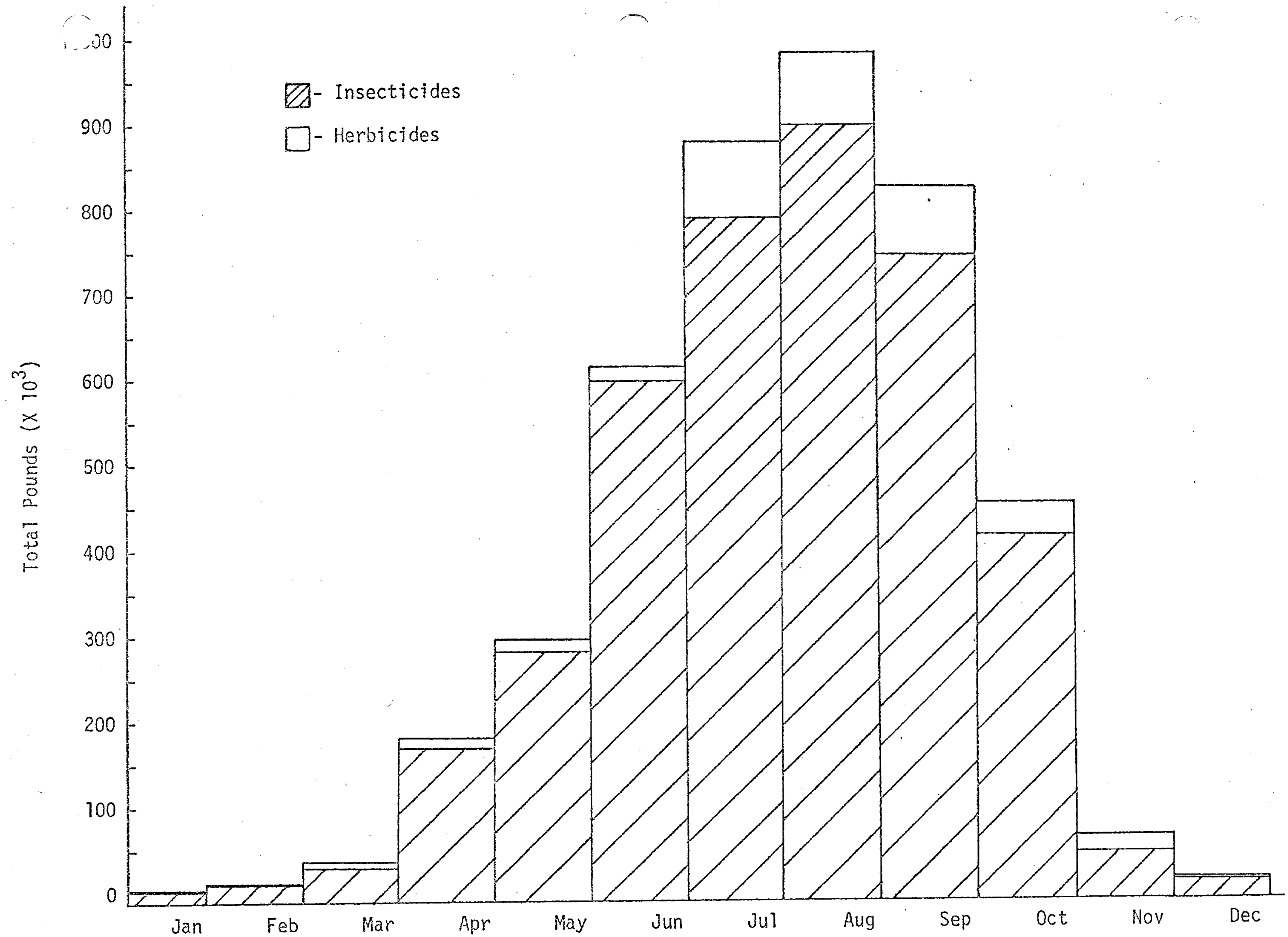

Figure A.3-2. Monthly Distribution of Nonsynthetic Hydrocarbons Applied by Vector Control in 1977.

Herbicides. Application of herbicidal weed oils by vector control totaled 275,179 pounds (76.6 percent) and the remaining 84,127 pounds were diesel oil (see Table A.3-11). Distribution of these oils by month is also shown in Figure A.3-2.

Nonsynthetic hydrocarbons used for weed control normally accomplish a dual purpose. The primary objective is the destruction of aquatic or terrestrial weeds which serve as mosquito habitat (source reduction), thus making larvae more susceptable to natural predators. However, when so applied, the oils not only kill the vegetation but also act as a larvicide, creating a suffocating film on the water surface. This method is used extensively in the San Joaquin County dairy industry for mosquito control in dairy drains. The effluent from these locations is high in organic matter and provides excellent habitat for larvae development. Heavy oil applications (over 30 gallons/acre) are often required to control weeds under such conditions.

A.3.3.2.3 The Pest Problem

The mosquito is the specific target pest of vector control. The numerous species of mosquitos all develop through the same life stages and are susceptable to chemical, physical, and biological controls at the same states of maturation. Major emphasis of vector control is the elimination of larvae before they reach pest status as adults. Mosquito larvae are confined to aquatic habitats during their development but metamorphose into winged adults.

Larval stages are the weak link in the life cycle of this pest and are susceptable to the greatest variety of control methods. Because of this, present control programs are three fold directed primarily against larvae. Source reduction, that is, the elimination of standing water where possible, and the removal of vegitation from breeding habitats is a major goal of vector control. Fewer breeding and development sites for mosquitos will reduce pest populations. Biological control is another method employed which serves to disrupt developing populations. There are a few biocontrol agents which have proved very effective in reducing numbers of larvae. These are discussed below in Section A.3.3.2.7. The third method is chemical control which is the most expedient means to achieve rapid reduction in numbers, however, problems with resistance may reduce synthetic chemical effectiveness over time. No resistance has been found from using nonsynthetic hydrocarbons.[88]

A.3.3.2.4 Application Rates and Methods

Nonsynthetic hydrocarbon applications by vector control are almost exclusively by ground spray methods. Larvicidal oils are dripped or sprayed onto water surfaces at rates of one to five gallons per acre using hand held wands and mechanical booms. Herbicidal oils are applied with the same type of equipment but at much higher rates. Actual rate depends upon size, density, and types of weeds treated but generally follow recommended rates of 30 gallons per acre. In problem areas, such as dairy drains, rates may run as high as 50 gallons per acre.

Aerial applications of oils are impractical for this agency and are therefore infrequent. Extensive aerial treatments are performed (620,729 acres in 1977), however, these are primarily applications of synthetic chemicals.[86]

A.3.3.2.5 Advantages and Disadvantages

Oils function as dual purpose larvicide/herbicide products in many areas including dairy drains, sewage and waste treatment ponds, and standing water. Because of their effectiveness against target pests without the threat of resistance development, oils are essential tools for vector control. Oils can damage spray equipment when used for extended periods of time and are messy chemicals to apply.

A.3.3.2.6 Synthetic Pesticides

Synthetic chemicals used in vector control are applied as larvicides and adulticides in all 66 districts. Chemicals functioning as both include Malathion, Fenthion, Parathion and Dursban®. Malathion was the most widely used synthetic chemical contributing 81.6 percent of the reported synthetic usage[87] and is preferred by vector control applicators because of its effectiveness against both larvae and adult mosquitoes. Mosquito resistance to most all synthetic insecticides has precluded their use for varying periods of time in some locations.[88] Fenthion is receiving wide use because of its control effectiveness and non-toxic effect on honeybees. Parathion use is limited by resistance as is dursban and several other synthetic chemicals. Table A.3-12 lists the major products as reported in the 1977 Pesticide Use Report. Values shown here are contrary to these reported by the State Department of Health, Division of Vector Control.[86]

A relatively new synthetic pyrethroid, Pydrin® is receiving more research attention in several areas of pest control. It has been tested in aquatic environments for effectiveness on mosquito larvae and proved to be extremely effective. However, it is also very harmful to many other aquatic organisms.[89] Because of its biocidal properties, its use in aquatic environments is being discouraged.[88]

TABLE A.3-12

Synthetic Chemicals Used in Vector Control from 1977 Pesticide Use Report[a]

Chemical	Pounds Reported	Percent of Total
Malathion	154,960	81.6
Fenthion	16,991	8.9
Parathion	4,738	2.5
Dursban®	3,963	2.1
All Other Insecticide Compound	9,334	4.9
TOTAL	189,986	100.0

[a] The PUR value for malathion exceeds applications reported by State Department of Health, Vector Control by a factor of 8.7. Values for Fenthion, Parathion and Dursban® are under-reported in the PUR by factors of 1.2, 3.7, and 1.3 respectively. Total synthetics from PUR exceed Vector Control applications by a factor of 2.5.[86]

Resistance Factors in Mosquitoes. Resistance is a genetic character present in some mosquitoes. It is a process whereby specific enzymes are produced by the mosquito which can break down normally toxic chemicals into non-toxic by-products. Manufacturing these enzymes requires proteins. Since there is a limited reservoir of proteins available for synthetic, a shift in body functions takes place. The production of these proteins apparently causes a reduction in the egg laying capacity by up to 25 percent in resistance species.[88] Consequently, the number of eggs might be reduced from 400-600 eggs/female/year in non-resistant individuals to 300-450 eggs/female/year in resistant mosquitoes.[88]

Disappearance of the resistance factor from a population is dependent upon the length of time resistance has been selected for (i.e. the size of the resistant population) and whether or not the mosquito population is under stress due to the reduction in the egg laying capacity. If fewer eggs deposited per year imposes a hardship on the population, then production of the resistant enzyme might be reduced in favor of increased egg production. Unfortunately, it appears that a 25 percent reduction in egg laying capacity is not significant and it is estimated that a period of 10 years may be required before this factor "disappears" from the population and control is again possible with synthetic pesticides.[88]

During this period of resistance degeneration, oil becomes the key chemical control agent. Because the action of oil is physical (i.e. suffocation) mosquitoes do not become resistant, whereas, cross resistance may develop rapidly if alternate synthetics are used. This problem arises when a population has developed resistance to one organo phosphorus material. Subsequent treatments with a different synthetic will result in rapid build up of a population resistant to the new chemical while maintaining its resistance to the first organo phosphate.[90] This situation has already developed in most mosquito abatement districts in California.[91]

A.3.3.2.7 Biological Control

Introduction. Biological control has been an integral part of vector control strategies for a number of years. There are areas where synthetic and nonsynthetic pesticide use is limited or restricted (such as rice fields and residential areas), and non-chemical control methods are necessary. Biocontrol agents examined here include mosquito fish, planaria and hydra. Fourty-two districts (71.6 percent) were using one or more biological controls as part of their abatement programs in 1977.[86] Some districts experience few mosquito problems and therefore do not bother with extensive rearing and distribution of these agents.

Gambusia affinis. The mosquito fish, *Gambusia affinis*, is probably the most widely known and presently, the most widely used biocontrol agent in California against mosquitoes.[88] These fish suppress mosquito populations upon which they feed and are currently being used in 42 districts. Adequate control has not been achieved in field conditions to replace pesticides completely; however, significant reductions have occurred.[92,93]

Mosquito fish are susceptable to different organophosphate chemicals used in other control programs. Work by Mulla (1961, 1963, 1966) in this area showed malathion more toxic to fish than DDT and parathion causing 48-70 percent mortality at .5 lbs./acre. Parathion caused 18-30 percent mortality at .1 lb./acre while methyl parathion showed no mortality at the same rate.[94,95,96]

Where biological control programs are operating and mosquito fish are a part of this, care must be taken before synthetic sprays are applied to avoid disruption of fish population.

Gambusia must be restricted to certain habitats to be effective in biocontrol of mosquitoes. Aquatic habitats which are "too cold, too plant infested, polluted, lacking in protection from their own natural enemies, or simply too extensive or temporary for the fish to achieve mosquito controlling densities should be avoided.[93]

Effective populations of fish have been reported to be at concentrations of 1.2 to 2.2 fish per cubic foot of water.

Planaria. Dugesia dorotocephala (Woodworth) have been shown effective in destroying laboratory and field populations of mosquito larvae. Planaria are voracious eaters and often kill many more larvae than they consume. They are extremely difficult to kill and are able to survive for at least four months without food. They also have the capacity to go through a dormant stage if pond conditions are unfavorable. Rearing large numbers of these in a small area without cannabilism occurring is a great advantage in mass production. The semi-dormant eggs can be sprayed onto ponds with conventional spray equipment.[97]

Control of mosquito larvae has been obtained at 25 planaria per square yard. More concentrated populations exert greater suppressive action. They survive in most polluted waters and appear to be a great asset to biocontrol and IPM programs. The planaria larvae secretes a mucus substance which has shown larvacidal effects on mosquitoes. Research is currently under way to determine the potential of this substance.[97,98]

Hydra. A relative of the jellyfish, the tiny hydra are voracious eaters also and destroy large numbers of mosquito larvae. They are easily introduced into rice fields in large numbers and exert considerable control over mosquito populations. Current research is being conducted in Kern County rice fields to determine their suitability as large scale control agents.[99]

A.3.3.2.8 Integrated Pest Management

Vector control districts are actively involved in integrated pest management to varying degrees depending upon individual needs. IPM programs involve the three aspects discussed in the section on pest problems (A.3.3.3.3); physical (source reduction), biological, and chemical control. These are used in combinations as required in different areas. IPM has been very successful in Marin County saltmarshes in reducing pesticide applications and insect populations.[100] As with IPM programs in all areas, mosquito control involves close monitoring of populations and sprays or alternative control methods directed at high concentrations of adults or larvae. Maximum utilization of biological control agents and maximum source reduction are all necessary for optimum success of any IPM program.

A.3.3.2.9 Insect Growth Regulators

Insect growth regulators (IGR) hold promise for mosquito control in the future. Research currently underway is seeking to determine the practicality of these compounds.

Two products which have proven effective as IGR's are Methoprene, manufactured by Zoecon Corporation, and TH-6040 (diflurbenzuron or Dimilin) a product currently being considered for a mosquito control label by the Environmental Protection Agency. IGR's prevent large larvae from maturing into adults thus causing them to die before they can leave their aquatic habitat. Success has been high in laboratory experiments and field trials are currently underway.[101]

A.3.3.3 Creosote Wood Preservation

A.3.3.3.1 Introduction

Many wood species have some degree of natural resistance to decay, but all wood products, regardless of their original strength, durability or natural resistance, are subject to some degree of degradation when placed in conditions where the wood is susceptible to attack by fungi, insects or bacteria.

The life of properly treated wood can be increased by a factor of five or more using present-day preservatives although the actual life varies depending on the intensity of use, climate, environment and other factors.[102]

The primary wood products preserved in California during 1977 with some form of creosote included railroad crossties, poles, piling, lumber and timber.

A.3.3.3.2 Background

1. Description of the California Wood Preserving Industry. There were 13 wood preserving plants in operation in California during 1976 of which 11 were pressure treating plants, one was non-pressure treating and one was a combination pressure and non-pressure treating plant. Four of the California plants used creosote and/or oil borne preservatives, and all four of the plants used pressure cylinders for the preservative treatment.[102]

2. Application Methods. The method by which preservatives are impregnated into wood is nearly as important in determining the treatment effectiveness as the type of preservative used. The desired characteristics of a good application method are an ability to secure a deep and reasonably uniform penetration with a preservation retention appropriate to the ultimate end use of the product. For some purposes such as window sash and millwork, adequate preservation can be accomplished throug the use of relatively cheap, non-pressure processes such as dipping, steeping, brushing and spraying. However, for most industrial purposes, adequate protection requires the use of pressurized processes designed to force the preservatives into the wood.[102]

3. <u>Pressure Treatment</u>. Pressure treatment of wood with preservatives is by far the most effective method of protecting wood against attack by wood-destroying agents. Through pressure treatment, deeper and more uniform penetration of preservative can be obtained, and the retention of preservatives can be more closely controlled. Additionally, maximum production of preserved forest products can best be achieved through pressure impregnations, since the time required to thoroughly impregnate wood is held to a minimum.[103]

Pressure processes are performed in steel cylinders that range in size from 4-10 feet in diameter and up to 175 feet in length and are capable of withstanding pressures up to 200 psi.[103]

There are two basic procedures for pressure treating wood. The full-cell process is designed to achieve maximum retention of liquid preservative in the wood by filling the wood cells. The empty-cell process is designed to achieve the same depth of penetration but with lower retention rates by merely coating the walls of the wood cells. Neither process actually leaves the wood cells completely full or empty, but the names of the two processes are descriptive of the basic theory behind the two procedures.

4. <u>Non-Pressure Treatment</u>. Many different types of non-pressure processes have been utilized for treating wood. The most commonly used methods for treatment of lumber, piling and posts consist of various combination of dipping, soaking, and steeping wood in hot and/or cold preservative baths. Brush and

spray treatments are used on wood that is already part of a structure. The effectiveness of non-pressure processes depends to a large extent on the properties of the wood.[102]

A.3.3.3.3 Creosotes and Creosote Solutions

Preservatives in the creosote family consist of complex mixtures of organic oils and tars which are derived primarily from by-products formed during coal distillation, coal tar refining and petroleum refining. Creosote contains a large and variable number of organic chemicals that have various inhibiting effects on wood deteriorating organisms. Of the many varieties of creosotes and related materials, only coal tar creosote and mixtures of coal tar creosote with crude coal tar or petroleum oils are recognized as preservatives in the United States.[102]

Almost every aromatic hydrocarbon, tar acid and tar base have been identified in various batches of creosote. Because the composition of creosote is subject to such variations, it is assayed and specified by its physical characteristics including water content specific gravity, impurities and its fractional distillation curve. The importance of the fractional distillation curve relates to the fact that the components of the various distillation fractions display different toxicities to wood deteriorating organisms. They also exhibit varying volatilities and solubilities in water, both affecting the relative permanence of the treatment.[102]

Creosote is the dominant preservative used for railroad ties and piling but has been surpassed in quantity by petachlorophenol and copper arsenate for the treatment of other wood products. In most situations, creosote performs very well by itself. However, in some situations, it may be blended with crude coal tar or petroleum oils. Addition of coal tar may reduce the cost of the preservative, and reduce the tendency of treated wood to check or split in service which can allow entry to wood destroying organisms and result in early failure.

Creosote-petroleum solutions have similar advantages and disadvantages to those of creosote-coal tar solutions except that the petroleum oils do not increase the toxicity of the preservative. However, petroleum oils do increase the weather resistance of the wood, stabilize the moisture content of the wood and reduce subsequent checking. For these reasons, creosote-petroleum solutions are used for railroad ties in the less decay-prone, arid areas of the western U.S.[102] An additional quality of creosote-petroleum treated ties is the lubricating effect the oil has on the wood allowing it to be more resilient and reducing the tendency of the tie to broom-out on the ends and require replacement.

A.3.3.3.4 Advantages and Disadvantages of Creosote

The principal advantages of creosote are its marked toxicity to wood destroying fungi, insects and some marine borers; its relatively low volatility and its insolubility in water, which accounts for its long, useful like; its ease of handling and application; the ease with which its retention and penetration may be determined; and its general availability and economy. For these reasons, creosote is particularly well suited in preservation of railroad crossties, fence posts, lumber and timbers, crossarms, poles and pilings. However, creosoted products are subject to some disadvantages which sometimes impair the usefulness of creosote for purposes other than commercial and industrial applications. These include color, odor, oily and unpaintable surfaces and a tendency to bleed.[102]

Creosote vapors cause eye and nose irritation. Liquid creosote is a primary skin irritant but is not an eye irritant. The irritation thresholds for eyes, nose and throat have not been determined. Photo sensitization has been reported, and fair skin men are reportedly sensitive to creosote while dark skin workers show remarkable resistance. Cutaneous carcinomas have been reported. Creosote is classified as a toxic substance, but the magnitude of this toxicity is low. The LD_{50} for albino rats given a single oral dose is estimated to be 1.7 gm/kg of body weight. This LD_{50} would be approximately equivalent to a 4 oz. dose for a 150 lb. man.[104]

Currently, the Environmental Protection Agency has initiated a rebuttable presumption against registration (RPAR) for coal tar creosote, inorganic arsenic and pentachlorophenol wood preservatives. This action was initiated against coal tar, creosote and coal tar neutral oil because they have been found to exceed certain risk criteria set forth in 40 CFR 162.11. The basis for this action is detailed in the RPAR position document which gives data that associates creosote with human skin and eye irritation, livestock fatality, and fetotoxicity in test animals.[105]

The RPAR was initiated against registration of pesticide products containing pentachlorophenol because scientific studies have shown that these products exceed the risk criterion for teratogenicity and fetotoxicity.

Pentachlorophenol is classified as a toxic substance. The LD_{50} for pentachlorophenol given orally to rats is 27-80 mg/kg of body weight. Additionally, the presence of certain compounds called chlorinated dibenzo dioxins in commercial pentachlorophenol has recently caused much conern for the safety of this product to man and the environment. The concern originates mainly because of the fact that some chlorinated dioxin compounds are very highly toxic. Recent studies have indicated that the presence of these dioxins in commercial products can be responsible for certain adverse effects.

However, over the past 30 years there has been much less "pure" penta marketed than is used today, and there has been no record of industrial health problems among users in either the millwork industry or wood treating industry.[104]

The use of arsenical salts in pesticidal products which include wood preservatives is also being reviewed because it is presumed that these arsenic containing products exceed the 40 CFR risk criteria relating to oncogenic effects (human epidemiology studies), mutagenic effects, and reproductive or fetotoxic effects in mammolian test species.

The wood preserving industry has said that through the Wood

Preservers Institute they would respond to any RPAR, if issued, addressing the toxicity issues raised, showing that the exposures and risks involved are minimal and that the benefits (which cannot practically be supplied by alternatives) are great.[106]

A.3.3.3.5 Use Pattern of Creosote in California

Because the railroads are the primary consumers of creosoted wood products in California, the NSHC wood preservative consumption for each county is assumed to be proportional to the total miles of railroad track located in each county. Additionally, the monthly use distribution is assumed to be the same in every county and was derived from the monthly use pattern provided by one of the creosote treatment plants that responded to the questionnaire survey. Table A.2-3 describes the monthly distribution of creosote and creosote/petroleum usage by county in California during 1977.

A.3.3.3.6 Alternatives to the Use of Creosote

Like each of the preservatives in use today, creosote has end use limitations imposed by its chemical and physical properties. It is generally considered a relatively unclean preservative because it is prone to bleed and will often leave a sticky surface residue. Because of this and its oily nature, treated material cannot be finished or painted. Additionally, its volatility produces an odor that is objectionable and precludes its use in enclosed space and interior construction.

Determination of the feasibility of replacing creosote with alternative preservatives or substitute materials involves a number of considerations, including: the actual technical feasibility of the substitution, the availability and cost of raw materials, the cost of modifying existing facilities for production of new products with adequate pollution control, and the change in total energy demand resulting from the switch to the new products.[102]

Creosote and creosote solutions can be replaced with pentachlorophenol for preservation of many wood products including railway ties. Because of similarities in conditioning and treating processes, no significant new energy needs are expected at treatment plants following substitution of creosote with pentachlorophenol. The lower viscosity of pentachlorophenol solutions would result in a treating cycle which is 25 to 40 percent shorter than that for creosote. Additionally, the temperature during the pressure period is usually lower for pentachlorophenol than for creosote and creosote solutions, and pre-heating the preservatives is usually not suggested for pentachlorophenol. Assuming all other conditions are equal, the net energy required by a plant using pentachlorophenol would be lower than that required by a creosote treatment plant.[102]

It has been suggested that if creosote were to become unavailable, the production cost of treating wood products would be lowered.[102] However, this estimation was made without considering crossties which made up a large percentage of creosoted wood because data was not available for alternatives to creosote treated ties.

Near-term alternatives are primarily limited to preservatives presently in use, due in part to the long periods of time required for adequate testing of new preservatives. Pentachlorophenol (penta) is the predominant preservative used for poles, crossarms and fence posts and is also important in the treatment of lumber and timbers and non-pressure treatment of millwork. An advantage of penta is that the preservative characteristics are due to one chemical whose concentration may be easily controlled to optimize its toxicity, cost and cleanliness.[102] Penta is oil soluble so the usual treatment is an oil borne treatment. However, penta is also used in the Cellon® and Dow® processes where the carriers are liquid petroleum gas with ether and methylene chloride respectively. The penta is left in the wood as a crystaline solid and the carrier solvents are recovered. Cellon® or Dow® treated wood has the advantage of being clean, dry and paintable with only a small amount of evaporative hydrocarbon loss.[a]

Waterborne preservatives are essentially a combination of insoluble metalic salts which are precipitated in the wood during treatment. The use of waterborne salts is appealing since the preservative solution penetrates wood easily, is easy to work with and provides a clean, odorless and paintable product at a relatively low cost. Additionally, the newer arsenicals are

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[a] The vapor pressure of pentachlorophenal being 0.00017 torr @ 20°C and 0.0031 torr @ 50°C suggests that it can volatilize from treated surfaces.

also resistant to leaching. However, some disadvantage of water-borne preservatives are that the wood must be well dried before treatment, that the wood is subject to swelling and shrinking as it is saturated and dried, that these treatments do not provide any physical protection to the wood, that the metals are extremely corrosive, and that some of the metals have significant mammalion toxicities.[102]

A survey of eight of the 20 largest wood preservers was made during 1976 to determine the relative costs involved with the different preservatives.[102] The survey results suggest a clear and consistent cost pattern. Water-borne preservative treatment tends to be more cost effective on "lighter" products (e.g. more on lumber than on timber and more on timber than on pile) when compared to creosote and penta with oil but less cost effective on "heavier" products. Creosote, by contrast, appears to be the most cost effective on "heavier" products and the least on "lighter" products. Penta however, at least based on initial cost comparison, does not appear to be a least-cost alternative for any single product.[102]

In the pacific region of the U.S., which includes Washington, Oregon, California and Hawaii, creosote use was slightly greater than that of pentachlorophenol during 1977.[107] If there were use limitations on creosote, the most serious impacts would fall upon the producers and users of treated ties and pilings with lesser impacts upon producers and users of lumber, posts and other products.

Alternatives to the use of creosote for treating railway ties. Creosote, either alone or in combination with coal tar or petroleum is almost invariably used for the treatment of railway ties. Some of the reasons for this preferred use are its water repellent qualities, its lubricating properties, minimization of checking and splitting, proven efficiency against decay and termites, and its traditional use by the railroads.[102]

Should creosote be unavailable for the preservation of railroad ties, two possible alternatives appear feasible at this time. The first of these would be preservation of ties with pentachlorophenol in heavy petroleum. Ties treated with pentachlorophenol are apparently satisfactory in northern latitudes as has been demonstrated by Canadian experience, but performance in southern latitudes is of yet uncertain and may depend upon factors such as the species of wood used.[102]

However, since heavy oils contain many of the same aromatic compounds potentially considered objectionable in creosote, restriction of creosote could also mean condemnation of the former in which case this alternative for creosote treated ties would no longer be feasible.

Waterborne salts generally are not suited for the treatment of railway ties because they make the wood brittle and give less protection against mechanical wear.

Alternatives to the use of creosote for treating poles. In recent years there has been a shift in treating poles with creosote to pentachlorophenol. Pentachlorophenol is generally preferred for several reasons: it is less expensive than creosote, it produces a clean pole, and it produces a lighter colored "aesthetic" pole. Arsenicals can also be used to treat poles. However, they do have some undesireable characteristics that have prevented their widespread use for this application.

Poles treated with arsenicals are harder and more brittle than those treated with creosote. This characteristic makes poles hard to climb with climbing spikes. Additionally, climbing spikes may cause splitting of the wood, decreasing the life of the pole and possibly making it less safe to climb. It seems likely that creosote and pentachlorophenol will remain in competition for the treatment of poles.[102]

Alternatives to the use of creosote for treating lumber. Most of the lumber products treated with creosote are timbers used for bridges and other industrial structures and crossarms of utility poles. In most cases, either pentachlorophenol or arsenicals could be substituted for this use. However, in the case of large timbers and laminated members, waterborne salts could pose seasoning swelling problems, and for these cases, pentachlorophenol would be preferred.[102]

Besides replacing creosote with other preservatives that have less or no hydrocarbon emissions, modification of the creosote preservative can be done to decrease the amount of associated hydrocarbon emission. As was mentioned previously, addition of 2 percent pentachlorophenol to creosote produces a marked increase in vapor pressure which results in a decrease in creosote volatilization. Also, it was found that high (40 percent) residue creosote has less volatilization losses than low (20 percent)

CONCRETE

Major advantages of concrete include:
- concrete structures may be pre-cast off-site and erected later;
- concrete's load carrying capacity is higher than that of wood;
- concrete is pliable when freshly poured: it may be easily molded into a variety of non-standard shapes and sizes as well as into many identical components;
- raw materials may be obtained relatively easily;
- it is resistant to fire and weathering processes; and
- it is resistant to termite and fungal attack.

Major disadvantages of concrete may include:
- it weighs two to three times more than wood of equivalent strength;
- it is somewhat brittle for certain applications;
- it is generally not salvageable;
- in some cases it is more expensive than alternate materials; and
- the energy requirement for production of concrete is generally somewhat more than that for treated wood products.

STEEL

Major advantages of steel include:
- it has a very high strength;
- size limitations are much less severe than with any other construction material;
- it may be produced in any desired shape;
- its hardness and ductility can be controlled to a large degree;
- it is fire and decay resitant; and
- it requires very little maintenance for most uses.

In addition, weathering steels (such as ASTM-558) are now available which do not require painting.

Major disadvantages of steel may include:
- it weighs significantly more than wood;
- under some circumstances it is subject to corrosion;
- it conducts electricity, interfering with communication systems when used as ties and creating the potential for accidental grounding when used as utility poles. In both cases proper grounding is necessary;
- it is generally more expensive than wood; and
- the energy requirement for production of steel is approximately 5000 Btu per cubic inch (for sheet steel) ., somewhat more than that for treated wood products.

ALUMINUM

Major advantages of aluminum include:
- it is approximately 35 percent of the weight of steel;
- it is corrosion resistant;
- it is strong;
- it requires little maintenance;
- it is fire and decay resistant;
- it has a high salvage value;
- it may be produced in any desired shape; and
- it is the most abundant metal in the earth's crust and therefore relatively easily obtainable (although it must be processed).

Major disadvantages may include:
- it has a tendency to buckle under compression: in order to support heavy loads, structures have to be made very thick, thereby losing any weight or cost advantage which might have been realized;
- it conducts electricity, and therefore requires grounding; and
- the energy requirement for production of aluminum, approximately 12,000 BTU per cubic inch for sheet aluminum, is higher than that for treated wood products.

FIBERGLASS

Major advantages of fiberglass include:
- it is a light weight material;
- it is a versatile design material which may be molded into a variety of shapes;
- it is resistant to insect attack;
- for small structures it is considerably cheaper than steel;
- it is easy to install;
- it does not rust or rot;
- it is self-extinguishing; and
- it is non-conducting.

Major disadvantages include:
- it lacks the stiffness necessary for heavy structural uses;
- there is a tendency for some resins to break down after prolonged exposure to ultraviolet radiation;
- large fiberglass structures (e.g., poles) are very expensive compared to wood.
- the energy requirement for production of fiberglass is approximately 3000 Btu per cubic inch somewhat more than that required for treated wood products.

residue creosote.

Structural alternatives for creosoted wood. Depending on the type and size of product desired, there may be alternative structural materials which could replace preserved wood. These include steel, concrete, fiberglass, aluminum, naturally, durable wood and various experimental materials such as foamed glass. Each of the materials present a different set of advantages and disadvantages.[102]

Steel and concrete are used extensively in heavy construction and other large building projects. Concrete railroad ties are also being used successfully by some railroad companies. The initial purchase and installation costs for concrete ties range anywhere from two to three times as much as for wood ties. However, an extremely long service life (estimates as high as 100 years) and relatively low maintenance are anticipated for these ties. Additionally, it is thought that rails will last longer when concrete ties are used and that this would more than offset the higher initial costs. Aluminum and fiberglass are competitive for smaller products such as posts and poles.

A.3.3.4 Utilities

The electric and telephone companies servicing California are the primary consumers of preserved wood poles. Many times, utility poles that are in place require the use of herbicides for controlling grasses and weeds that can be fire hazards. Therefore, a survey was made to determine the extent that creosote and weed oil was used by the utilities in California during 1977 for preserving wood and controlling weeds.

Summary of the survey is detailed in Table A.3-13. Most of the poles were treated with pentachlorophenol using the Cellon® or Dow® process which produces an "clean", dry pole that is esthetically acceptable or can be painted. The noteable exception to this is the use of pentachlorophenol in a petroleum solvent by Southern California Edison which set 15,000 poles in 1977 and by Pacific Telephone which set a small number of poles in the San Diego area.

It was reported that the dry poles treated by the Dow® and Cellon® processes were subject to checking in a hot, dry climate; therefore, poles treated with pentachlorophenol in petroleum are used because they appeared to last longer than the dry poles. Emissions data is not available for the treatment of these poles with pentachlorophenol in petroleum solvent because volatilization loss studies were not found in the literature for this treatment. However, the emissions would be small when compared to the rest of the industry which uses primarily pentachlorophenol with the Dow® or Cellon® treatment process with virtually all the carries recovered from the wood after treatment leaving only crystalline pentachlorophenol in the wood.

Weed control was primarily accomplished with synthetic herbicides although the Sacramento Municipal Utility District did report using 440 gallons of weed oil. This use of weed oil is an exception to the general observed trend of an apparent phasing out of weed oil use.

Because the large corporations have a greater ability to do

TABLE A.3-13

Pesticide Use by Some California Utilities for 1977[108,109]

Electric Utility	Percent of California Population Serviced	Pole Preservative Treatment Used in 1977	Weed Control Used in 1977
Southern California Edison Company	37	Pentachlorophenol in a petroleum solvent[119]	Simazine®[110]
Los Angeles Water and Power Company	24	Pentachlorophenol with the Dow® or Cellon® process	Mowing and some Ureabor®
Pacific Gas and Electric Company	34	Pentachlorophenol with the Cellon® process	Simazine®
Sacramento Municipal Utility District	2	Pentachlorophenol with the Cellon® process	Several synthetic herbicides plus 440 gallons of weed oil.
Telephone Company			
Pacific Telephone	79	Pentachlorophenol with the Cellon® process Waterborne chromated copper arsenage Pentachlorophenol in a pet-roleum solvent. (San Diego area only)	Synthetic herbicides

research and testing of materials, they are usually the trend setters for the smaller companies. Therefore, the assumption is made that the unsurveyed smaller utility and telephone companies serving the remainder of the California population and negligible quantities of weed oil, pentachlorophenol in petroleum or creosoted poles during 1977.

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A.4.0

IMPACTS ASSESSMENT OF ALTERNATIVES TO PESTICIDE OIL USE

A.4.1 HEALTH IMPACTS ASSESSMENT

TABLE A.4-1.

Acute Toxicity Data of Nonsynthetic and Synthetic Alternative Pesticides

Pesticide	Restricted Status	Oral LD 50 Values (mg/kg)	Toxicity Rating	Test Animals	Reference and Comments
Nonsynthetic Insecticide and Herbicide					
Kerosene	NR	50	2	rats	(3)
Xylene	NR	4300	1	rats	(4)
Coal tar creosote	NR	725	1	rats	(4)
Synthetic Insecticide					
Chlorobenzilate	NR	1000	1	rats	(5) not stored in body fat
Endosulfan	R	18	3	rats	(6)
Kelthane®	NR	684	1	rats	(5)
Carbophenothion	R	30	3	rats	(5) absorbed through skin
Diazinon	NR	300	2	rats	(5) may be through skin
Ethion	R	65	2	rats	(5) may be through skin
Guthion®	R	13	3	rats	(5) absorbed through skin
Malathion	NR	1375	1	rats	(5)
Parathion®	R	25.6	3	mice	(6)
Supracide®	R	66	2	rats	(5)
Carbaryl®	R	104	2	mice	(6)
Morestan®	NR	2500	1	rats	(5) may cause skin irritation but is not a skin sensitizer
Omite®	NR	2200	1	rats	(6)
Plictran®	NR	540	1	rats	(6) irritating to eyes
Pydrin®		451	2	rats	(5)
Rotenone	NR	132	2	rats	(5)
Synthetic Herbicide					
MSMA	NR	700-1800	1	rats	(7) less effective under 70°F or less
Phytar	NR	830	1	rats	(7) kills weeds under water conditions
Ramrod®	NR	710	1	rats	(5)
Trifluralin	NR	5000	1	rats	(7) strongly absorbed in soil, very toxic to fish
Diuron	NR	3400	1	rats	(7)
Tenoran	NR	3700	1	rats	(5)
Linuron	NR	1500	1	rats	(7) short life in soil
Terbacil	NR	5200	1	rats	(7) long residual
Prometryn	NR	3750	1	rats	(5)
Sencor	NR	1937	1	not specific	(7) pre-emergence and early post emergence
DCPA	NR	3000	1	rats	(5)
DNBP	NR	58	2	rats	(5) toxic to fish and birds, absorbed through skin
Paraquat	R	157	2	rats	(5) drift hazard to susceptible crops, high inhalation toxicity
CPIC	NR	3800	1	rats	(7)
Endothal	NR	38	3	rats	(5) irritating to eyes, nose, skin & throat, safe to fish
TOK-25®	NR	3630	1	rats	(7) short residue
DNBP (ammonium salt	NR	58	2	rats	(7) absorbed through skin
Sulfuric Acid	NR	1 oz. oral		lethal to humans	(7) highly corrosive to metal, skin, clothing
Tedion	NR	14700	1	rats	(5)

TABLE A.4-2.

Reported Illness and Injuries which Occurred among Workers Associated with Nonsynthetic and Synthetic Pesticides in 1977[2]

Number of cases reported, type of illness or injury (occupational code in parenthesis)

Pesticide	Systemic Illness	Sub-total	Eye Injuries	Sub-total	Skin Injuries	Sub-total	Eye & Skin Injuries	Sub-total	Total Cases Reported 1977
Nonsynthetic Insecticide									
Creosote	3(4)	3	13(4)	13	22(4)	22	2(4)	2	40
Dormant Spray					1(21)	1			1
Nonsynthetic Herbicide									
Weed Oils	3(1), 3(13), 2(27)	8	1(8), 1(10), 3(1), 1(7), 2(11), 1(24) 20(13)	29	7(1), 1(8), 2(13), 1(18) 1(23)	12	1(5), 1(14)	2	51
Synthetic Insecticide									
Halogenated Hydrocarbons									
Chlorobenzilate			1(1)	1					1
Endosulfan	1(21), 1(31)	2			1(18), 1(21)	2			4
Kelthane®	1(13), 2(27)	3	1(1), 1(11), 1(18)	3	1(1)	1			7
Organophosphates									
Diazinon	1(1), 2(8), 1(13), 1(14), 1(16), 1(17), 1(26), 8(27), 1(29), 1(32)	18	1(10), 1(13), 1(14), 4(16), 1(32)	8	1(1), 1(5), 1(11), 1(16), 1(27)	5	1(18)	1	32
Ethion®	1(21)	1							1
Guthion®	1(6), 1(7), 3(28), 2(32)	7			1(9)	1			8
Imidan®	1(1)	1			1(1)	1			2
Malathion	1(5), 2(11), 1(16), 3(17), 1(26), 1(32)	9	1(1), 1(8), 1(11), 2(16), 1(18)	6	1(1), 1(14), 1(16), 2(17), 1(27), 1(32)	7			22
Naled	2(21), 2(22)	4	2(1), 1(15)	3	1(11), 1(12)	2			9
Parathion	9(1), 2(7), 3(8), 24(21), 1(22), 1(23), 1(24), 4(26), 3(31)	49	1(1), 1(8)	2	1(1), 1(26)	2			53
Supracide®	1(21), 1(26)	2							2
Carbamates									
Carbaryl	1(11), 1(18), 1(22), 1(32)	4	1(1), 1(9), 1(16), 1(27)	4	1(1), 2(8)	3			11
Methomyl	6(1), 1(6), 2(8), 12(9), 2(18), 2(21), 3(22), 1(23), 1(24), 2(26), 7(28), 3(30), 1(31), 3(32)	46	6(1), 2(8), 1(25)	9					55

TABLE A.4-2. (Continued)

Reported Illness and Injuries which Occurred among Workers Associated with Nonsynthetic and Synthetic Pesticides in 1977[2]

Number of cases reported, type of illness or injury (occupational code in parenthesis)

Pesticide	Systemic Illness	Sub-total	Eye Injuries	Sub-total	Skin Injuries	Sub-total	Eye & Skin Injuries	Sub-total	Total Cases Reported 1977
Miscellaneous									
Omite®	4(1), 3(21), 1(23),1(32)	9	1(1)	1	1(1),1(9), 1(17),12(21), 1(24)	16			25
Plictran®			1(1)	1	2(1),1(22)	3			4
Synthetic Herbicides									
Organoarsenates									
MSMA	1(1), 1(8), 1(32),1(10),	3	2(1),1(23)	3	1(1)	1			7
Phytar	1(10)	1	1(11),1(32)	2	1(11),1(32)	2			5
Substituted Amides									
Ramrod®					1(1),1(32)	2			2
Dinitroanilines									
Trifluralin	2(21)	2	1(1),1(23)	2	1(1), 1(26)	2			6
Arylaliphatic Acids									
Dacthal®	1(21)	1							1
Phenols									
DNBP	1(32)	1	1(24),1(26), 1(32)	3	1(24)	1			5
Bipyridyls									
Paraquat	3(1), 1(8), 2(28)	6	3(1), 1(5), 1(8), 1(9), 1(18),1(24)	8	3(1), 1(8), 1(11)	5	1(12)	1	20
Miscellaneous									
Endothal			1(7)	1	1(31)	1			2
TOK-25®	1(21)	1			1(23)	1			2
Glyphosate	3(1), 1(2), 1(22),	5	3(1), 1(2), 1(8),2(11) 1(12)	8	3(1), 1(11), 1(8)	5			18
Vendex®	1(18)	1			1(1)	1			2
TOTALS		187		107		99		6	399

(1) Ground applicator (farm)
(2) Ground applicator (road)
(3) Mosquito Abatement worker
(4) Creosote worker
(5) Other applicators
(6) Aerial applicator
(7) Mixer/loader, (application
(8) method not stated)
(8) Mixer/loader, ground applicator
(9) Mixer/loader, aerial applicator
(10) Garden/maintenance,home
(11) Garden/maintenance,parks
(12) Garden Maintenance, golf course
(13) Garden/maintenance, public building
(14) Garden maintenance, commercial bldg.
(15) Termite operator
(16) Other structure
(17) Nursery/greenhouse, drift or residue
(18) Nursery/greenhouse, pesticide applicator
(19) Field fumigator
(20) Fumigator, other
(21) Field worker exposed to residue
(22) Outdoor worker exposed to drift
(23) Tractor driver/irrigator
(24) Cleaner/repairer
(25) Packer/processor
(26) Warehouse worker/transportation
(27) Indoor worker exposed to drift or residue
(28) Firemen exposed to pesticide fires or spills
(29) Policemen
(30) Flagger
(31) Manufacturing/formulation
(32) Other types of pesticide use

A.4.2 ENERGY IMPACT ASSESSMENT

TABLE A.4-3

Energy Content of Oil Substituted by Synthetic Alternatives in 13 Commodities

Commodity	Application (%)		Oil Use Equivalent Average Reduction (1000 acres)	Oil Use Reduction (1000 lbs)	Energy Consumption (10^6 Kcal)		
	Air	Ground			Manufacturing	Application	Total
Grapefruit Grapefruit	0 0	100 100	3.75	499	11,427	18	11,445
Lemon	0	100	47.65	6,122	140,194	230	140,424
Orange	0	100	27.00	3,543	81,135	130	81,265
Peaches	20	80	2.16	77.3	1,770	10	1,780
Plums	20	80	0.37	14.3	327	2	329
Prunes	20	80	7.64	234.5	5,370	37	5,407
Pears	20	80	9.25	802.6	18,379	45	23,831
Alfalfa	1	99	59.83	10,806.5	247,469	289	247,758
Avocado	0	100	5.3	1,240.2	21,299	25	21,324
Carrots	0	100	10.99	5,327.5	122,000	53	122,053
Citrus	0	100	42.7	3,650	62,689	206	62,895
Weed Control Unclassified	0	100	232.52[a]	88,359	2,023,421	1,122	2,024,543
School Districts	0	100	4.61[a]	1,751	40,098	22	40,120

a. Based on the assumption that the average application rate is 50 gallons per acre.

TABLE A.4-4

Energy Content of Synthetic Pesticides Serving as Alternatives to Oil in 13 Commodities

Commodity / Chemical	Application Distribution (%) Air	Ground	Average Annual Application Acreage (1000 acres)	Application Rate (lbs/acre)	Weight Applied Total (1000 lbs)	Energy Consumption (10^6 Kcal) Manufacture	Application	Total
Alfalfa								
Diuron	1	99	59.8	2.00	119.6	1,315.6	298.6	1,614.2
DNBP	1	99	"	1.68	100.5	1,105.5	"	1,404.1
Paraquat	1	99	"	0.63	37.7	414.7	"	713.3
CIPC	1	99	"	3.00	179.5	1,974.5	"	2,273.1
Metribuzin	1	99	"	0.63	37.7	1,105.5	"	1,404.1
Terbacil	1	99	"	6.80	47.9	526.9	"	825.5
Average					87.2	1,073.8	298.6	1,372.4
Carrots								
Trifluratin	0	100	11.0	0.75	8.25	91.1	54.8	145.9
Linuron	0	100	"	1.13	12.43	136.7	"	191.5
TOK-25®	0	100	"	6.00	66.00	726.0	"	780.8
CIPC	0	100	"	4.00	44.00	484.0	"	538.8
Average			"			359.4	54.8	414.2
Avocado								
Simazine	0	100	5.3	2.0	10.6	116.6	26.5	145.1
Paraquat	0	100	11	0.75	4.0	44	"	70.5
Average						80.5	26.5	107
Citrus								
DNBP + Oil (2 gals/acre)	0	100	42.7	29.65	1,266.0	13,926.0	213.1	14,139
Diuron	0	100	"	2.4	102.5	1,127.5	"	1,341

TABLE A.4-4 (cont'd)

Commodity / Chemical	Application Distribution (%) Air	Ground	Average Annual Application Acreage (1000 acres)	Application Rate (lbs/acre)	Weight Applied Total (1000 lbs)	Energy Consumption (10^6 Kcal) Manufacture	Application	Total
Citrus								
Simazine	0	100	"	3.0	128.1	1,409.1	"	1,622
Paraquat	0	100	"	0.75	32.0	352.0	"	565
Average						4,204	213	4,417
Prune								
Kelthane®			7.64	1.75	13.37	147.1	32.6	179.7
Carbophenthion			"	0.88	6.72	73.9	"	106.5
Average						110.5	32.6	143.1
Peaches								
Guthion® + Carbary			2.16	1.5	3.24	35.6	10.5	46.1
Kelthane®			"	1.74	3.76	41.4	"	14.6
Carbophenothion			"	0.88	1.90	20.9	"	12.6
Omite®			"	1.40	3.02	33.2	"	13.9
Average						3.3	10.5	13.8
Plums								
Kelthane®	20	80	0.37	1.75	0.65	7.1	1.9	9.0
Carbophenothion	20	80	"	0.88	0.33	3.6	"	5.5
Average						4.5	1.9	7.3
Pears								
Diazinon	20	80	9.25	1.05	9.71	106.8	44.6	151.4
Plietran®	20	80	"	0.50	4.63	50.9	"	95.5
Endosulfan	20	80	"	2.25	20.81	228.9	"	273.5

TABLE A.4-4 (cont'd)

Commodity Chemical	Application Distribution (%) Air	 Ground	Average Annual Application Acreage (1000 acres)	Application Rate (lbs/acre)	Weight Applied Total (1000 lbs)	Energy Consumption (10^6 Kcal) Manufacture	 Application	 Total
Pears								
Carbophenothion	20	80	"	1.00	9.25	101.8	"	146.4
Kelthane®	20	80	"	2.05	18.96	208.5	"	253.1
Ethion	20	80	"	1.00	9.25	101.8	"	111.1
Average						123.1	44.6	167.7
Grapefruit (A)								
Parathion	0	100	3.75	4.45	16.69	183.6	18.1	201.7
Malathion	0	100	"	10.50	39.38	433.2	"	451.3
Carbaryl	0	100	"	4.70	17.63	193.9	"	212.0
Guthion®	0	100	"	12.70	47.63	523.9	"	542.0
Supracide®	0	100	"	6.70	25.13	276.4	"	294.5
Parathion & Malathion	0	100	"	2.50	9.38	103.2	"	121.3
Average						285.7	18.1	303.8
Grapefruit (B)								
Ethion	0	100	3.75	3.50	13.12	144.3	18.1	162.4
Omite®	0	100	"	3.85	14.44	158.8	"	176.9
Plietran®	0	100	"	1.45	5.44	59.8	"	77.9
Vendex®	0	100	"	1.00	3.75	41.2	"	59.3
Morestan®	0	100	"	1.88	7.05	77.6	"	95.7
Kelthane®	0	100	"	4.00	15.00	165	"	183.1

TABLE A.4-4 (cont'd)

Commodity / Chemical	Application Distribution (%) Air	Application Distribution (%) Ground	Average Annual Application Acreage (1000 acres)	Application Rate (lbs/acre)	Weight Applied Total (1000 lbs)	Energy Consumption (10^6 Kcal) Manufacture	Energy Consumption (10^6 Kcal) Application	Energy Consumption (10^6 Kcal) Total
Grapefruit (B)								
Average						107.8	18.1	125.9
Grapefruit Average (A&B):								429.7
Lemon (A)								
Parathion	0	100	47.65	4.45	212.0	2,332.0	230.0	2,562.0
Malathion	0	100	"	10.50	500.3	5,503.3	"	5,733.3
Carbaryl	0	100	"	4.70	224.0	2,464.0	"	2,694.0
Guthion®	0	100	"	12.70	605.2	6,657.2	"	6,887.2
Supracide®	0	100	"	6.70	319.3	3,512.3	"	3,742.3
Parathion & Malathion	0	100	"	2.50	119.1	1,312.1	"	1,542.1
Average						3,630.2	230.0	3,860.2
Lemon (B)								
Ethion	0	100	47.65	3.50	166.8	1,834.9	230.0	2,064.8
Omite®	0	100	"	3.85	183.5	2,018.5	"	2,248.5
Plictran®	0	100	"	1.45	69.1	760.1	"	990.1
Vendex®	0	100	"	1.00	47.6	523.6	"	753.6
Morestan®	0	100	"	1.88	89.6	985.6	"	1,215.6
Kelthane®	0	100	"	4.00	190.6	2,096.6	"	2,326.6
Average						1,202.0	230.0	1,432.0
Lemon (C)								
Chlorobenzilate			47.65	4.75	226.3	2,489.3	230.0	2,719.3
Lemon Average (A,B,C):								8,011.2

TABLE A.4-4 (cont'd)

Commodity / Chemical	Application Distribution (%) Air	Application Distribution (%) Ground	Average Annual Application Acreage (1000 acres)	Application Rate (lbs/acre)	Weight Applied Total (1000 lbs)	Energy Consumption (10^6 Kcal) Manufacture	Energy Consumption (10^6 Kcal) Application	Energy Consumption (10^6 Kcal) Total
<u>Orange (A)</u>								
Parathion	0	100	27.00	4.45	120.2	1,322.2	130.3	1,452.5
Malathion	0	100	"	10.50	283.5	3,118.5	"	3,248.8
Carbaryl	0	100	"	4.70	126.9	1,395.6	"	1,525.9
Guthion®	0	100	"	12.70	342.9	3,771.9	"	39,002.2
Supracide®	0	100	"	6.70	180.9	1,989.9	"	2,120.2
Parathion & Malathion	0	100	"	2.50	67.5	742.5	"	872.8
Average						2,056.8	130.3	2,187.1
<u>Orange (B)</u>								
Ethion			2.70	3.5	9.5	103.9	13.0	116.9
Omite®			"	3.85	10.40	114.4	"	127.4
Plictran®			"	1.45	3.9	43.1	"	56.1
Vendex®			"	1.00	2.7	29.7	"	42.7
Morestan®			"	1.88	5.1	55.9	"	68.9
Kelthane®			"	4.00	10.8	118.8	"	131.8
Average						77.6		90.6
Orange Average (A&B):								2,277.7
<u>School Districts</u>								
Glyphosate	0	100	4.61	2.25	10.40	114.4	22.2	136.6
Cacodylic Acid	0	100	"	5.00	23.1	254.1	"	276.3
Amitrol-T	0	100	"	5.85	27.0	296.7	"	318.9

TABLE A.4-4 (cont'd)

Commodity Chemical	Application Distribution (%) Air	 Ground	Average Annual Application Acreage (1000 acres)	Application Rate (lbs/acre)	Weight Applied Total (1000 lbs)	Energy Consumption (10^6 Kcal) Manufacture	 Application	 Total
School Districts								
Average						221.7	22.2	243.9
Weed Control								
Unclassified								
Glyphosate	0	100	232.5	2.25	523.1	5,754.1	1,121.8	6,875.9
Diuron	0	100	"	3.60	837.0	9,207.0	"	10,328.8
Cacodylic Acid	0	100	"	5.00	1,162.5	12,787.5	"	13,909.3
Dinoseb	0	100	"	2.50	581.3	6,394.3	"	7,516.1
Simazine	0	100	"	25.0	5,812.5	63,975.5	"	65,097.3
Paraquat	0	100	"	0.75	174.4	129.1	"	1,250.9
Average						16,374.6	1,121.8	17,496.4

TABLE A.4-5

Energy Saving Due to Oil Use Reduction by Partial Switching to Low Volume and New Sprayer Application Methods in 10 Crops

Crop	Application (%)		Applied Acreage Reduction, Average	Oil Use Reduction (1000 lbs.)	Energy Savings (Kcal x 10^6)		
	Air	Ground			Manufacture	Application	Total
Grapefruit	0	100	:938	124.7	2,856	4.5	2,861
Lemon	0	100	10,729	1,378.4	31,566	51.7	31,618
Orange	0	100	6,750	885.7	20,282	32.6	20,315
Almond	20	80	11,455	403.9	9,251	55.6	9,307
Apricot	20	80	859	18.6	425.9	4.1	430
Nectarine	20	80	624	23.8	545.0	3.0	548
Peach	20	80	9,003	321.4	7,360.0	43.5	7,404
Plum	20	80	2,308	88.8	2,033.5	11.1	2,045
Prune	20	80	4,999	153.5	3,515.1	24.1	3,539
Pear	20	80	3,303	120.3	2,754.9	16.0	2,771

TABLE A.4-6

Energy Saving Due to Oil Use Reduction by Partial Switching to IPM in 3 Crops

Crop	Application (%)		Applied Acreage Reduction	Oil Use Reduction (1000 lbs.)	Energy Savings (Kcal x 10^6)		
	Air	Ground			Manufacture	Application	Total
Grapefruit	0	100	1,500-3,376	199.6-449.0	4,771-10,282[a]	7.2[a]	4,578-10,289
Lemon	0	100	19,057-42,879	2,448.3-5,508.6	56,066-126,147[a]	91.9[a]	56,158-126,239
Orange	0	100	10,800-24,300	1,417.1-3,188.4	32,452-73,014[a]	52.2[a]	32,504-73,066

[a]The energy use of parathion, a synthetic pesticide used in the IPM procedure, has been included in the consideration.

A.4.3 ECONOMIC IMPACTS ASSESSMENT

TABLE A.4-7

Total Annual Cost of Nonsynthetic Pesticide Treatments for Selected Uses

Nonsynthetic Oil	Recommended Application Rate (gal/acre)	Av. Cost of Oil ($/gallon)	Total Application Volume (gal/acre)	No. of Applications	Annual Recommended Oil Application Volume (gal/acre)	Cost of Material ($/acre)	Application Cost ($/acre)	Total Annual Cost ($/acre)[c]	1977 Estimated Total Annual Cost ($/acre)[d]
Alfalfa Weed Oil	D 25-70	.50	75-210	1	25-70	12.5-37.5	5.00	17.5-40.0	15.75
Summer Desiccation	A 15	.50	15	1.25	18.8	9.4	3.10	12.50	13.09
Carrot Weed Oil	C 30-50	.50	30-50	1.25	37.5-62.5	18.8-31.3	3.50	23.1-35.6	66.54
	50-100	.70	50-100	1.25	62.5-125	43.8-87.5	4.00	47.75-91.5	
Avocado Weed Oil	D 30-60	0.50	30-180	2.5	75-150	37.5-75	4.00	47.50-85.00	64.73
Citrus Weed Oil	D 30-60	0.50	30-180	2.5	75-150	37.5-75	4.00	47.50-85.00	38.56
Almond Cormant	D 12 C 8	1.00	400-450 100	1 1	12 8	13.7[b] 13.2[b]	10.00 5.00	53.05-69.65	59.45
Foliar Oil	D 4-6	1.58	400-450	2	8-12	14.0-20.4[b]	10.00		
	C 4-6		100	2	8-12	14.0-20.4[b]	5.00		
Apricot Foliar Oil	D a	1.58	400-450	3	26-43	42.76-69.62[b]	10.00	72.94-82.43	51.20
Peach & Nectarine Foliar Oil	D a	1.58	400-450	4	16-30	26.12-48.24[b]	10.00	66.12-88.24	83.25
	C a		100	4	21	35.8[b]	5.00	75.80	
Plum & Prune Foliar Oil	D a	1.58	400-450	4.25	16-30	40.85-62.97[b]	10.00	83.35-105.47	78.00
	C a		100	4.25	13.8-20	27.0-36.7[b]	5.00	48.3-58.0	
Pear Foliar Oil	D a	1.58	400-450	4.25	32.40	54.60-67.24[b]	10.00	97.10-109.74	125.80
	C a		100	4.25	17	43.2[b]	5.00	64.5	
Citrus Foliar Oil	23-26	1.58	1,500	1.25	29.9-32	45.4-51.4	10.00	57.9-63.8	56.71
School District	30-70	0.50	30-100	2	60-160	30.00-80.00	4.00	38.00-88.00	42.80
Weed Control Unclassified	30-80	0.50	30-100	2	60-160	30.00-80.00	4.00	38.00-88.00	87.50

A - Aerial Spray
C - Concentrated Spray
D - Dilute or High Volume Spray

a - Quantity of oil applied per acre is the same as Table 7-3.
b - Includes the cost of synthetic materials.
c - Based on recommended application rate.
d - 1977 estimated total annual cost was calculated with 1977 values for application rates.

TABLE A.4-8

Total Annual Cost of Synthetic Pesticide Treatments for Selected Uses

Synthetic Treatments	Active Ingredient (lb/acre)	Price of Active Ingredient ($/lb)	Total Gallons of Spray Per Acre	No. Applications Per Year	Cost of Material ($/acre)	Application Cost ($/acre)	Annual Cost Per Chemical ($/acre)	Annual Treatment Cost for Crop (Use), ($/acre)
Alfalfa								3.1-21.8
Diuron	1.6-2.4	5.00	40-60	1	8-12	4.00	12-15	
DNBP	1.25-1.91	4.00	40-60	1	5-7.6	4.00	9-11.6	
Paraquat	0.5-0.75	21.00	40-60	1	10.5-15.3	4.00	14.5-19.8	
CIPC	2-4	4.00	40-60	1	8-16	4.00	12.20	
Metribuzin	0.25-1	18.30	10-40	1	4.5-18.3	3.50	3.1-21.8	
Terbacil	0.4-1.2	14.39	40-60	1	5.8-17.3	4.00	9.3-21.3	
Carrots								10.0-46.0
Trigluralin	0.75	8.00	40-60	1	5.00	4.00	10.00	
Linuron	0.75-1.5	11.00	40-60	1	8.3-16.5	4.00	12.3-20.5	
TOK-25®	6	7.00	40-60	1	42.0	4.00	46.0	
CIPC	4	4.00	40-60	1	16.0	4.00	20.0	
Avocado								7.25-98.40
Simazine	2.0	3.25	50	1	3.25	4.00	7.25	
Paraquat	0.5-1.0	20.60	100	1-4	10.30-82.40	4.00	14.30-98.40	
Citrus								11.70-71.4
Dinoseb + Oil	1.25-10	4.00	100	1-4	6.00-41.00	4.00	10.00-164.00	
Diuron	1.6-6.4	5.00	100	1-2	8.00-64.00	4.00	12.00-80.00	
Simazine	2.0-4.0	3.25	100	1	6.50-13.00	4.00	10.50-17.00	
Paraquat	0.5-1.0	20.60	100	1-4	10.30-20.60	4.00	14.30-24.60	
Almond								23.0-39.0
Ethion	D 1.0 C 0.75	5.62	400 100	2.5	14.3 10.5	10.00 5.00	39.0 23.0	
Carbophenothion	D 1.0 C 1.0	5.44	400 100	2.5	13.6 13.6	10.00 5.00	38.5 26.1	
Apricot								38.3
Kelthane®	D 1.9	7.00	400	1	13.3	10.00	23.3	
Carbophenothion	1.0	5.44	400	1	5.4	10.00	15.0	
Peach & Nectarine								45.9-82.3
Guthion® plus Carbaryl	1. 2.	9.30 2.36	400	1	14.0	10.00	24.0	
Kelthane®	D 1.9 C 1.4-1.75	7.0	400 100	2.5	33.3 24.5-30.6	10.00 5.00	58.3 37.0-43.1	
Carbophenothion	D 1. C 0.75	5.44	400 100	2.5	13.6 10.2	10.00 5.00	38.6 22.7	
Omite®	D 1.3 C 1.5	2.50	400 100	2.5	8.1 9.4	10.00 5.00	33.1 21.9	

TABLE A.4-8 (cont'd)

Synthetic Treatments	Active Ingredient (lb/acre)	Price of Active Ingredient ($/lb)	Total Gallons of Spray Per Acre	No. Applications Per Year	Cost of Material ($/acre)	Application Cost ($/acre)	Annual Cost Per Chemical ($/acre)	Annual Treatment Cost for Crop (Use), ($/acre)
<u>Plum & Prune</u>								13.2-55.3
Kelthane®	D 1.9	9.30	400	2	35.3	10.00	55.3	
	C 1.6		100		29.8	5.00	39.3	
Carbophenothion	D 1.0	5.44	400	2	10.9	10.00	30.9	
	C 0.75		100		8.2	5.00	18.2	
<u>Pear</u>								37.20-97.5
Diazinon	D 1.0	5.00	400	1.5	9.00	10.00	24.00	
	C 1.1		100		9.90	5.00	17.40	
Plictran®	D 0.5	33.00	400	1.5	24.80	10.00	39.80	
	C 0.5		100		24.80	5.00	32.30	
Endosulfan	D 2.0	3.46	400	1.5	25.40	10.00	40.40	
	C 2.5		100		31.70	5.00	39.20	
Carbophenothion	D 1.0	4.90	400	2	9.30	10.00	29.80	
	C 1.0		100		9.80	5.00	19.80	
Kelthane®	D 2.0	9.30	400	2	37.20	10.00	57.20	
	C 2.1		100		39.10	5.00	49.00	
Ethion	D 1.0	5.52	400	2	11.20	10.00	31.20	
	C 1.0		100		11.20	5.00	21.20	
<u>Citrus</u>								38.7-138.3 (orange & grapefruit)
Parathion	D 4.8-5.8	3.45	1,000	1	16.6-20.	10.00	26.6-30.	
	C 3.6		100		12.40	5.00	17.40	
Malathion	D 8.7-12.3	3.50	1,500	1	30.5-43.1	10.00	40.5-53.1	50.3-156.1 (lemon)
Parathion plus	D 3.6+	3.45+	1,500	1	12.40+	10.00	42.70	
Malathion	5.8	3.50			12.30-32.70			
Carbaryl	D 11.5-13.9	2.36	1,500	1	27.10-32.30	10.00	37.1-42.8	
Gutnion®	D 6.-7.4	9.30	1,500	1	55.8-68.8	10.00	65.8-78.3	
Supracide®	D 2.5	9.00	1,000	1	20.40	10.00	30.4	
Ethion	D 3.5	5.62	1,000	1	19.70	10.00	29.7	
Omite®	D 3.2	2.50	1,000	1	8	10.00	18.00	
	D 4.5		1,500		11.30	10.00	21.30	
Plictran®	D 1.4	33.00	1,000	1	46.20	10.00	56.20	
	D 1.5		1,500	1	49.50		59.50	
Morestan®	C 1.0	29.80	100	1	29.80	5.00	34.80	
Vendex®	D 1.3-2.5	23.60	1,000	1	30.7-59.00	10.00	40.7-69.00	
	C 1.5-2.0		100	1	35.4-47.20		45.4-57.20	
Kelthane®	D 4.0	7.00	1,000	1	28.00	10.00	38.00	
	C 4.0		100			5.00	33.00	
Chlorobenzilate (lemon only)	D 1.7	4.75	1,000	1	8.10	10.00	18.10	
	C 1.5		100		7.10	5.00	12.10	

TABLE A.4-8 (cont'd)

Synthetic Treatments	Active Ingredient (lb/acre)	Price of Active Ingredient ($/lb)	Total Gallons of Spray Per Acre	No. Applications Per Year	Cost of Material ($/acre)	Application Cost ($/acre)	Annual Cost Per Chemical ($/acre)	Annual Treatment Cost for Crop (Use), ($/acre)
Olive								25.40
Parathion	D 3	3.45	600	1.25	12.90	10.00	25.40	
School District								25.20-177.75
Glyphosate	1.5-3.0	15.00	150	2.25	50.60-101.25	4.00	59.60-110.25	
Cacodylic Acid	5.0	15.00	100	2.25	168.75	4.00	177.75	
Amitrol-T	1.8-9.9	4.00	100	2.25	16.20-89.10	4.00	25.20-98.10	
Weed Control Unclassified								22.50-134.00
Glyphosate	1.5-3.0	15.00	100	2	45.00-80.00	4.00	53.00-98.00	
Diuron	3.2-4.0	5.00	100	1-5	24.00-30.00	4.00	30.00-36.00	
Cacodylic Acid	5	15.00	100	2	150.00	4.00	158.00	
Dinoseb	1.25-3.75	4.00	60-100	2-5	12.50-37.50	4.00	22.50-47.50	
Simazine	10-40	3.25	100	1	32.50-130.00	4.00	36.30-134.00	
Paraquat	0.5-1.0	20.60	100	2-5	25.75-51.50	4.00	35.75-61.50	

A.4.4 AIR QUALITY IMPACTS ASSESSMENT

TABLE A.4-9

Estimated Emission Reduction from Different Alternatives in San Joaquin County

Crop and Calendar Quarter	Estimated Quantity Applied (pounds)	Synthetic Pesticides Oil Reduction			Application Methods Oil Reduction			IPM Oil Reduction			
		(%)	Application (lbs)	Emission (lbs)	(Mean) (%)	Application (lbs)	Emission (lbs)	(%)	Application (Range) (lbs)	Application (Mean) (lbs)	Emission (Mean) (lbs)
Orange											
1st	0	100	0	363	LV Sp 12.5	0	45	45-90	0	0	245
2nd	0	"	0	394	LV Sp 12.5	0	49	45-90	0	0	266
3rd	5,268	"	5,268	3,797	LV Sp 12.5	658	475	45-90	2,371-4,741	3,556	2,563
4th	2,634	"	2,634	2,282	LV Sp 12.5	329	285	45-90	1,185-2,371	1,778	1,540
Almond											
1st	1,110,231	0	0	0	LV 12.5	138,779	97,164				
2nd	117,699	0	0	0	LV 12.5	14,712	29,741				
3rd	0	0	0	0	LV 12.5	0	1,641				
4th	0	0	0	0	LV 12.5	0	105				
Peach											
1st	102,882	3	3,086	2,441	LV 12.5	12,860	10,885				
2nd	2,881	"	86	252	LV 12.5	360	1,110				
3rd	0	"	0	0	LV 12.5	0	6				
4th	439	"	13	0	LV 12.5	55	52				
Pear											
1st	25,325	25	6,331	3,004	LV 12.5	3,166	2,174				
2nd	2,190	"	548	1,141	LV 12.5	274	736				
3rd	0	"	0	97	LV 12.5	0	92				
4th	0	"	0	14	LV 12.5	0	17				
Plum											
1st	11,662	2	233	181	LV 12.5	1,458	1,131				
2nd	1,296	"	26	55	LV 12.5	162	345				
3rd	0	"	0	2	LV 12.5	0	15				
4th	0	"	0	0	LV 12.5	0	0				
Alfalfa											
1st	5,853,116	50	3,926,558	2,217,824							
2nd	0	"	0	398,497							
3rd	0	"	0	6,737							
4th	0	"	0	0							
Carrot											
1st	15,120	48	7,258	6,877							
2nd	36,120	"	17,338	16,616							
3rd	24,360	"	11,693	11,265							
4th	16,800	"	8,064	7,696							
School District											
1st	14,732	50	7,366	6,955							
2nd	20,833	"	10,417	9,891							
3rd	17,542	"	8,771	8,363							
4th	8,006	"	4,003	3,790							
Weed Control Unclassified											
1st	2,659,951	75	1,994,963	1,881,920							
2nd	12,490,600	"	9,367,950	8,897,367							
3rd	5,109,127	"	3,831,845	3,655,603							
4th	2,844,703	"	2,133,527	2,018,427							
QUARTERLY TOTALS											
1st	8,911,718		5,945,795	4,119,565		156,263	111,399			0	245
2nd	12,671,619		9,652,210	9,324,193		15,508	31,981			0	266
3rd	5,156,297		3,857,577	3,685,864		658	2,229			3,556	2,563
4th	2,872,582		2,148,241	2,032,209		384	459			1,778	1,540
TOTAL	29,612,216		21,603,823	19,161,831		172,813	146,068			5,334	4,614

LV = Low volume sprayer application.

Sp = Improved coverage sprayer application.

TABLE A.4-10

Estimated Emission Reduction from Different Alternatives in Monterey County

Crop and Calendar Quarter	Estimated Quantity Applied (pounds)	Synthetic Pesticides Oil Reduction (%)	Synthetic Pesticides Oil Reduction Application (lbs)	Synthetic Pesticides Oil Reduction Emission (lbs)	Application Methods Oil Reduction (Mean) (%)	Application Methods Oil Reduction Application (lbs)	Application Methods Oil Reduction Emission (lbs)
Apricot							
1st	11,271	0	0	0	LV 12.5	1,409	1,098
2nd	0	"	0	0	LV 12.5	0	156
3rd	0	"	0	0	LV 12.5	0	17
4th	0	"	0	0	LV 12.5	0	0
Carrot							
1st	1,437,601	48	690,049	652,964			
2nd	2,247,146	"	1,078,630	1,024,439			
3rd	1,903,675	"	913,764	588,844			
4th	0	"	0	0			
School District							
1st	10,883	50	5,442	5,136			
2nd	15,401	"	7,701	7,288			
3rd	12,960	"	6,480	6,144			
4th	5,917	"	2,959	2,796			
Weed Control Unclassified							
1st	2,154,758	75	1,616,069	1,583,305			
2nd	10,503,047	"	7,877,285	7,452,779			
3rd	7,307,418	"	5,480,564	5,194,178			
4th	2,395,802	"	1,796,852	1,696,955			
QUARTERLY TOTALS							
1st	3,614,513		2,311,560	2,241,405		1,409	1,098
2nd	12,765,594		8,963,616	8,484,506		0	156
3rd	9,224,053		6,400,808	5,789,166		0	17
4th	2,401,719		1,799,811	1,699,751		0	0
TOTAL	28,005,879		19,475,795	18,214,828		1,409	1,271

LV = Low volume sprayer application.

TABLE A.4-11

Estimated Emission Reduction from Different Alternatives in Tulare County

Crop and Calendar Quarter	Estimated Quantity Applied (pounds)	Synthetic Pesticides Oil Reduction (%)	Synthetic Pesticides Oil Reduction Application (lbs)	Synthetic Pesticides Oil Reduction Emission (lbs)	Application Methods Oil Reduction (Mean) (%)	Application Methods Oil Reduction Application (lbs)	Application Methods Oil Reduction Emission (lbs)	IPM Oil Reduction (%)	IPM Oil Reduction Application (Range) (lbs)	IPM Oil Reduction Application (Mean) (lbs)	IPM Oil Reduction Emission (Mean) (lbs)
Grapefruit											
1st	0	100	0	41	LV Sp 12.5	0	5	45-90	0	0	28
2nd	659	"	659	626	LV Sp 12.5	82	78	45-90	297-593	445	423
3rd	0	"	0	0	LV Sp 12.5	0	0	45-90	0	0	0
4th	549	"	549	457	LV Sp 12.5	69	57	45-90	247-494	371	308
Lemon											
1st	0	100	0	0	LV Sp 12.5	0	0	45-90	0	0	0
2nd	856	"	856	742	LV Sp 12.5	107	93	45-90	385-770	578	501
3rd	0	"	0	70	LV Sp 12.5	0	9	45-90	0	0	47
4th	220	"	220	207	LV Sp 12.5	28	26	45-90	99-198	149	140
Orange											
1st	33	100	33	998	LV Sp 12.5	4	4	45-90	15-30	22	674
2nd	18,504	"	18,504	17,464	LV Sp 12.5	9,541	2,183	45-90	8,327-16,654	12,490	11,788
3rd	41,398	"	41,398	35,262	LV Sp 12.5	5,175	4,408	45-90	18,629-37,258	27,944	23,802
4th	17,949	"	17,949	19,371	LV Sp 12.5	2,244	2,421	45-90	8,077-16,154	12,116	13,075
Almond											
1st	404,399	0	0	0	LV 12.5	50,550	40,281				
2nd	0	0	0	0	LV 12.5	0	6,225				
3rd	0	0	0	0	LV 12.5	0	433				
4th	33,602	0	0	0	LV 12.5	4,200	2,791				
Apricot											
1st	12,938	0	0	0	LV 12.5	1,617	1,251				
2nd	0	0	0	0	LV 12.5	0	228				
3rd	0	0	0	0	LV 12.5	0	8				
4th	0	0	0	0	LV 12.5	0	0				
Nectarine											
1st	363,236	0	0	0	LV 12.5	45,405	34,859				
2nd	0	"	0	0	LV 12.5	0	5,775				
3rd	4,687	"	0	0	LV 12.5	586	912				
4th	0	"	0	0	LV 12.5	0	65				

TABLE A.4-11 (cont'd)

Crop and Calendar Quarter	Estimated Quantity Applied (pounds)	Synthetic Pesticides Oil Reduction (%)	Synthetic Pesticides Oil Reduction Application (lbs)	Synthetic Pesticides Oil Reduction Emission (lbs)	Application Methods Oil Reduction (Mean) (%)	Application Methods Oil Reduction Application (lbs)	Application Methods Oil Reduction Emission (lbs)	IPM Oil Reduction (%)	IPM Oil Reduction Application (Range) (lbs)	IPM Oil Reduction Application (Mean) (lbs)	IPM Oil Reduction Emission (Mean) (lbs)
Peach											
1st	216,678	3	6,500	4,435	LV 12.5	27,085	21,205				
2nd	0	"	0	795	LV 12.5	0	3,313				
3rd	0	"	0	46	LV 12.5	0	219				
4th	5,971	"	0	139	LV 12.5	746	587				
Plum											
1st	399,060	2	7,981	6,650	LV 12.5	49,883	41,563				
2nd	3,250	"	65	715	LV 12.5	406	4,468				
3rd	1,387	"	28	48	LV 12.5	173	303				
4th	8,240	"	165	148	LV 12.5	1,030	924				
Prune											
1st	134,659	25	33,665	26,074	LV 12.5	16,832	13,037				
2nd	0	"	0	1,747	LV 12.5	0	2,337				
3rd	0	"	0	48	LV 12.5	0	24				
4th	0	"	0	0	LV 12.5	0	2				
Citrus, Herbicide											
1st	438,000	100	438,000	396,823							
2nd	2,025,750	"	2,025,750	1,940,433							
3rd	704,450	"	704,450	677,118							
4th	481,800	"	481,800	446,958							
School District											
1st	13,303	50	6,652	6,276							
2nd	18,820	"	9,410	8,948							
3rd	15,839	"	7,920	7,601							
4th	7,232	"	3,616	2,929							
Weed Control Unclassified											
1st	1,378,419	75	1,033,814	974,826						22	707
2nd	6,473,348	"	4,855,011	4,619,258							
3rd	2,647,842	"	1,985,882	1,908,450							
4th	1,454,099	"	1,090,574	1,047,192							
QUARTERLY TOTAL											
1st	3,360,725		1,526,645	1,416,123		191,376	152,205			22	707
2nd	8,541,187		6,910,255	6,590,728		10,136	24,700			13,513	12,712
3rd	2,785,603		2,739,678	2,628,643		5,934	6,316			27,944	23,849
4th	2,009,662		1,594,873	1,517,401		8,317	6,873			12,636	13,523
TOTAL	19,482,364		12,771,451	12,152,895		215,763	190,094			54,115	50,786

LV = Low volume sprayer application.

Sp = Improved coverage sprayer application.

A.5.0

STATEMENTS CONTRIBUTED BY PROJECT CONSULTANTS

Statement on the use of NSHC herbicide use on selected vegetable row crops prepared by Mr. William Harvey, U.C. Cooperative Extension Weed Specialist.

BACKGROUND IN THE USE OF OILS AS GENERAL CONTACT HERBICIDES.

Use of weed oils on non-crop areas such as roadsides, fence rows, ditchbanks, around farm buildings and storage yards, rights-of-way, and industrial areas has been an accepted practice for many years in California. It is a major use of these oils.[1]

The use of oils as general contact herbicides developed because they were available in California, cheap, and gave good control of most weeds, including grasses. An important characteristic of oils is that they wet plant surfaces readily and creep into the crowns of grass plants. Early weed oils were crude diesels or heavier fractions, or heavy ends resulting from refining processes such as cracking or solvent extraction. They were of little commercial value at the time and sold cheaply as smudge pot fuel or bunker grade fuel for ships.

Smudge pot oil was used for many years for weed control in Southern California because it was available and cheap. It resulted in the development of non-tillage in citrus groves. Diesel fuel was widely used by many ranchers not only for general weed control but also in orchards, again because it was available from their same bulk tanks that provided tractor fuel.

With changes in refining practices and increasing demand for motor fuels with more exacting requirements, it was found that not all oil fractions were good weed killers. The demand for oils for weed killing purposes had, however, developed to the point that a number of oil companies found this market worth developing and provided oils, at a price, that were consistent in their properties for killing weeds. Early research such as that of Crafts and Reiber[2] resulted in a better understanding of what was needed to make an oil useful as a herbicide.

In general it was found that for general contact activity, the oil should have a high percentage of aromatics, a low unsulfonated residue (U.R.) and an A.P.I. gravity somewhat below that of diesel. There are still no exact specifications for a general contact weed oil. Some companies prepare specific oils for the purpose while others use a particular refining cut that has no other greater economic value. As crude oil has increased in price and factions such as gasoline and diesel oil become more valuable, the price of weed oils has likewise increased and this increase in cost is likely to continue. At the same time, quantities are likely to decrease as new refining techniques produce a higher percentage of more valuable fractions.

Other methods of weed control on non-crop areas include hand hoeing, mowing, discing or other mechanical cultivation, and flaming or burning. All have some disadvantages, such as cost, soil disturbance and erosion, air pollution from smoke and dust and difficulty of operating equipment in many non-crop areas. Biological control is at present effective on only a very few weed species on non-crop land. Russian thistle is controlled to some extent in certain areas of the state but not in others.

Weed oil is probably the safest of the herbicides for general use in many non-crop situations although some substitution can be made with various of the alternative herbicides listed. The price increases alone will result in reduced oil use for weed control. Specific weed problems can often be handled by other methods but may result in other species becoming a problem. A combination of two or more of the other methods may be the best substitute for the highly non-selective weed oil. Use restrictions such as permits and required closed system sprayers will discourage use of certain of the substitutes. Cost for substitute methods vary widely with the specific weed problem or use but become less critical as the price of weed oil increases. Numerous substitutions could be made with but little differences in cost to the grower at present prices. Lack of availability (rather than price concerns) of weed oil will most likely force a shift.

Carrots

The major herbicide for weed control in carrot production is a light oil fraction usually marketed as "carrot oil', stoddard solvent, or 350 thinner, with an A.P.I. gravity of 38° or above. It is applied as a broadcast spray with a ground rig at 40-80 gallons per acre using relatively large nozzles and a spray pressure of 40-80 p.s.i. It may be applied preemergence 2-3 days before the crop emerges but after the weeds have emerged, although the usual application is postemergence when the carrots are in the 2-4 leaf stage and the weeds are no more than 2 inches high. A second application may be necessary on some fields. The monthly use pattern of reported F-10 oils used on carrots during 1977 is shown in Figure A.5-1.

Most seedling weeds, except those in the carrot family, are controlled by the oil spray, and it is especially effective on yellow nutsedge an increasingly important weed in agricultural areas. Disadvantages to the oil spray are the large volumes of oil required, the fact that it is a contact spray that kills only the weeds that have germinated, and the possibility of an oily flavor in the carrots if a heavier oil fraction is used, if the spray treatment is delayed or the carrots harvested early as bunching carrots.

Costs of the oil vary with volume used but are approximately 70¢ per gallon (and increasing). Application cost will vary with locality and acreage treated but are \$6-\$8 per acre. It is not a cheap treatment.

If weather and field conditions permit, an early postemergence treatment

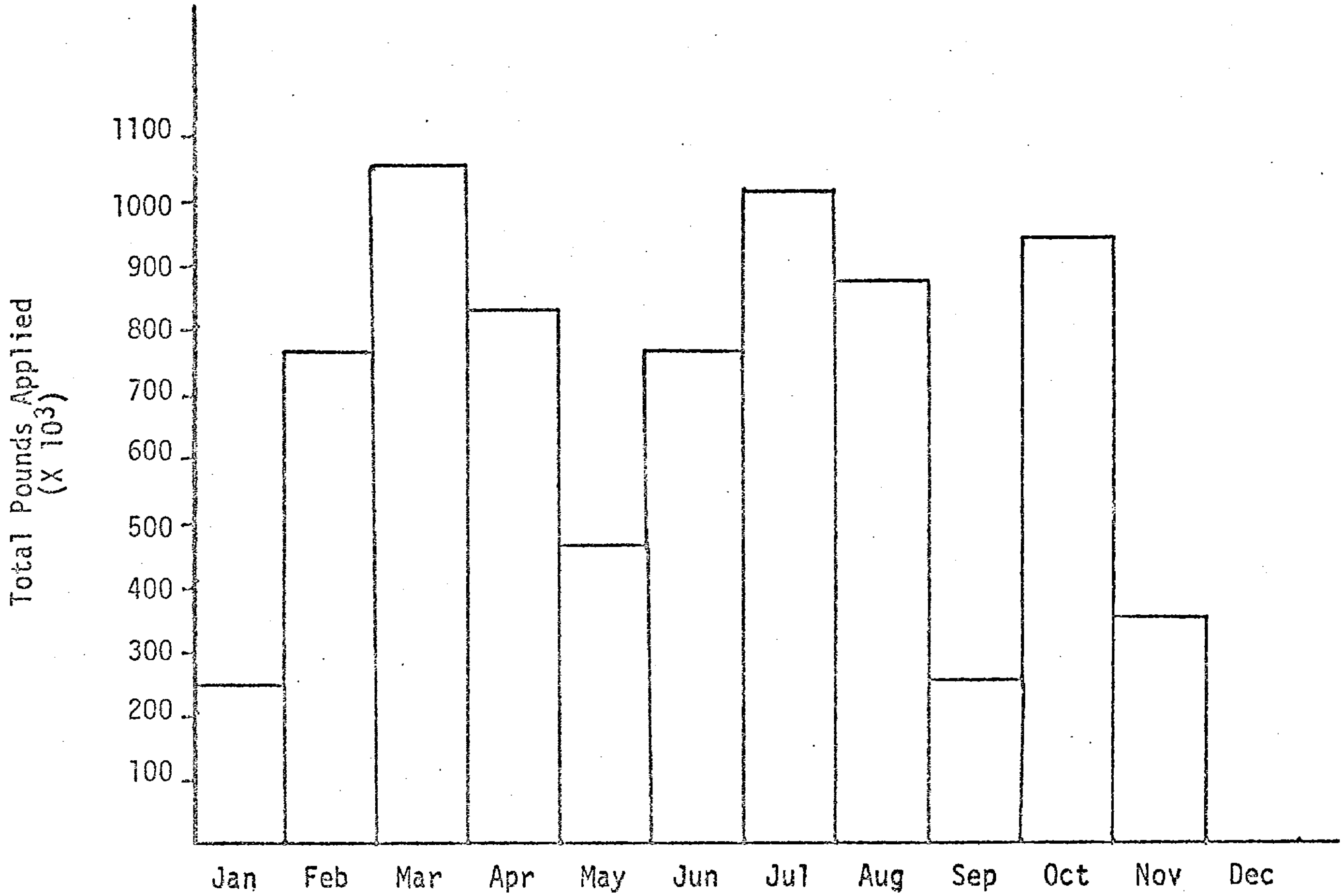

Figure A.5-1. Monthly Distribution of Reported F-10 Oils Used on Carrots in 1977 when weeds are small may allow the lower volume of oil to be used, but all the weeds must be wet with the spray. And later germinating weeds may necessitate a second treatment. Current practice may include a second, later treatment with linuron (LOROX®) or chloroxuron (TENORAN®). These are possible alternatives in their own right but are not total substitutes for the early oil spray. Both are more effective on broad-leaved weeds than on grasses and are ineffective on yellow nutsedge.

Linuron is usually applied postemergence after the carrots are 3 inches high and in the 4 leaf stage at rates of 3/4-1½ lbs/acre as a broadcast spray in 40-60 gallons of water per acre. The lower rate should be used on light (sandy) soils and there is a 4 month restriction against planting succeeding crops other than those on the linuron label. It is not effective on yellow nutsedge, Russian thistle, and some of the annual grasses. Although it may be used as the only herbicide treatment on carrots it is most often used, following an early oil spray, to give control of later germinating weeds. It fails as a substitute for oil because of lack of control of nutsedge and the lack of statewide availability (it is currently not sold in Kern County).

The cost of the chemical is about $5.00 per pound, and has the same application cost as for oil. Linuron has some foliage activity but most of its effectiveness is through root absorption, and it is thus not directly comparable to oil.

A somewhat similar alternate herbicide is chloroxuron which may be used at 2-4 pounds per acre either preemergence or postemergence after the carrot plants have formed true leaves. Irrigation may be necessary if no rain falls immediately after application as a preemergence treatment. It is not effective on soils high in organic matter such as peat or muck soils. Numerous weed species are not controlled, including sow-thistle, sweet clover, nutsedge and certain grasses. There may also be a soil residual for several months which could affect subsequent crops. Again, it is usually used to follow an oil treatment. The cost of the chemical is about $11.00 per pound and there has been a recent announcement that the chemical will no longer be manufactured. This will make the continued availablity of stoddard solvent even more vital to carrot producers.

Another herbicide used on carrots is nitrofen (TOK®). It is applied as a broadcast spray at 6 pounds per acre in 40-60 gallons of water, either preemergence or postemergence 2 weeks after the carrots emerge. It has a short residual in the soil and is rendered ineffective by cultivation. It does, however, work well under sprinkler irrigation. Numerous weeds are resistant, including mustards, chickweed, groundsel and some annual grasses. The cost is $6-$7 per pound. In some areas there is limited use of trifluralin (TREFLAN®) at 3/4-1 pound per acre applied preplant and incorporated into the soil. It is not effective on nightshade but gives good late season grass control. The cost is about $10.00 per pound.

In summary, none of these herbicides really substitute for stoddard solvent in providing adequate weed control in carrots, particularly in the very early growth stage. They are of use in addition to the oil treatment to give a longer period of control. The further question of continued availability of both linuron and chloroxuron limit their possible use to replace oil.

Weeding costs with hand labor in the past have run to $300.00 per acre and would be greater today if hand labor was available. There are no biological controls for the major weed pests of carrots today although a

Herbicides Use For Weed Control in Carrots in California

HERBICIDE	RATE/ACRE ACTIVE INGREDIENT	SPRAY VOL. WATER/ACRE	TIME OF APPLICATION	WEEDS CONTROLLED	REMARKS
Carrot Oil (Stoddard Solvent)	50-100 gal.	Undiluted	After crop has 2 true leaves, before root is 1/4 in. in diameter	Annual weeds, temporary control of yellow nutsedge	Spray during cool weather if possible. Use fresh oil only.
Trifluralin (TREFLAN®)	0.75 lb.	40-60 gal.	Preplant	Annual weeds	Incorporate 2 in. into soil immediately after application. Sensitive crops planted after carrot harvest may be damaged. See label for specific crops and waiting period.
Linuron (LOROX®)	0.75-1.5 lb.	40-60 gal.	After carrots reach 4 in. stage, postemergence application only	Annual weeds	Younger carrots may show excessive injury. Use low rate on light soils and high rate on heavy soils. Do not apply within 2 wks. of a carrot oil application. Do not plant to other crops within 4 mos. after treatment.
Nitrofen (TOK®)	6 lbs.	40-60 gal.	Pre or post emergence 2 weeks after a crop emergence	Annual weeds	
Chlorpropham (FURLOE®)	6.5 lbs. 4.0 lbs.	40-60 gal.	Preemergence post emergence before carrots have 5 true leaves or roots are 1/4 in. in diameter	Annual weeds	

Herbicides Use For Weed Control in Carrots in California cont.

HERBICIDE	RATE/ACRE ACTIVE INGREDIENT	SPRAY VOL. WATER/ACRE	TIME OF APPLICATION	WEEDS CONTROLLED	REMARKS
Chloroxuron (TENORAN®)	3-4 lbs 3-4 lbs.	40-60 gal. 40-60 gal.	Preemergence-irrigate within 2 days if no rain postemergence over the top after true leaves form	Annual weeds	Not for use on peat or muck soils

SOURCES: 1972 Crop Weed Control Recommendations, U.C. Div. of Agricultural Science

Pesticide Use Report by Commodity, 1977, C.D.F.A.

EPA Compendium of Registered Pesticides, Vol. 1, Supplement 4. 3/30/77.

possibility has been recently reported for nutsedge. At the very best this is several years in the future.

Mechanical cultivation is useful and is used between the rows or beds of carrots but cannot handle the weed problems near the young plants where competition is most severe.

At present there is no acceptable alternative to stoddard solvent for weed control in carrots. Increasing cost of oil will limit its use to situations where it is really needed. Synthetic herbicides are also increasing in cost and the astronomical costs of registration of new herbicides provides a dim future for possible new carrot herbicides.

Celery

The pattern of oil use on celery is different than on carrots in that it is more often used preemergence or pretransplant. Celery is less tolerant of the oil used postemergence than are carrots. The total use in the state is very much less for celery although the PUR shows a larger acreage treated with the stoddard solvent than with any other herbicide. The monthly use pattern of reported F-10 oils used on celery during 1977 is shown in Figure A.5-2. The oil serves a valuable purpose, however, in providing early season weed control, particularly of nutgrass.

Although not substitutes for stoddard solvent, other herbicides are used in celery as common practice. Probably the most widely used is prometryn (CAPAROL®) applied at 3.2 pounds per acre broadcast on transplanted celery only within 2-6 weeks after transplanting. It gives good control of chickweeds and groundsel but is weak on control of grasses. The cost is about $6.00 per pound.

Nitrofen is used on celery at the same rate as on carrots. It can be

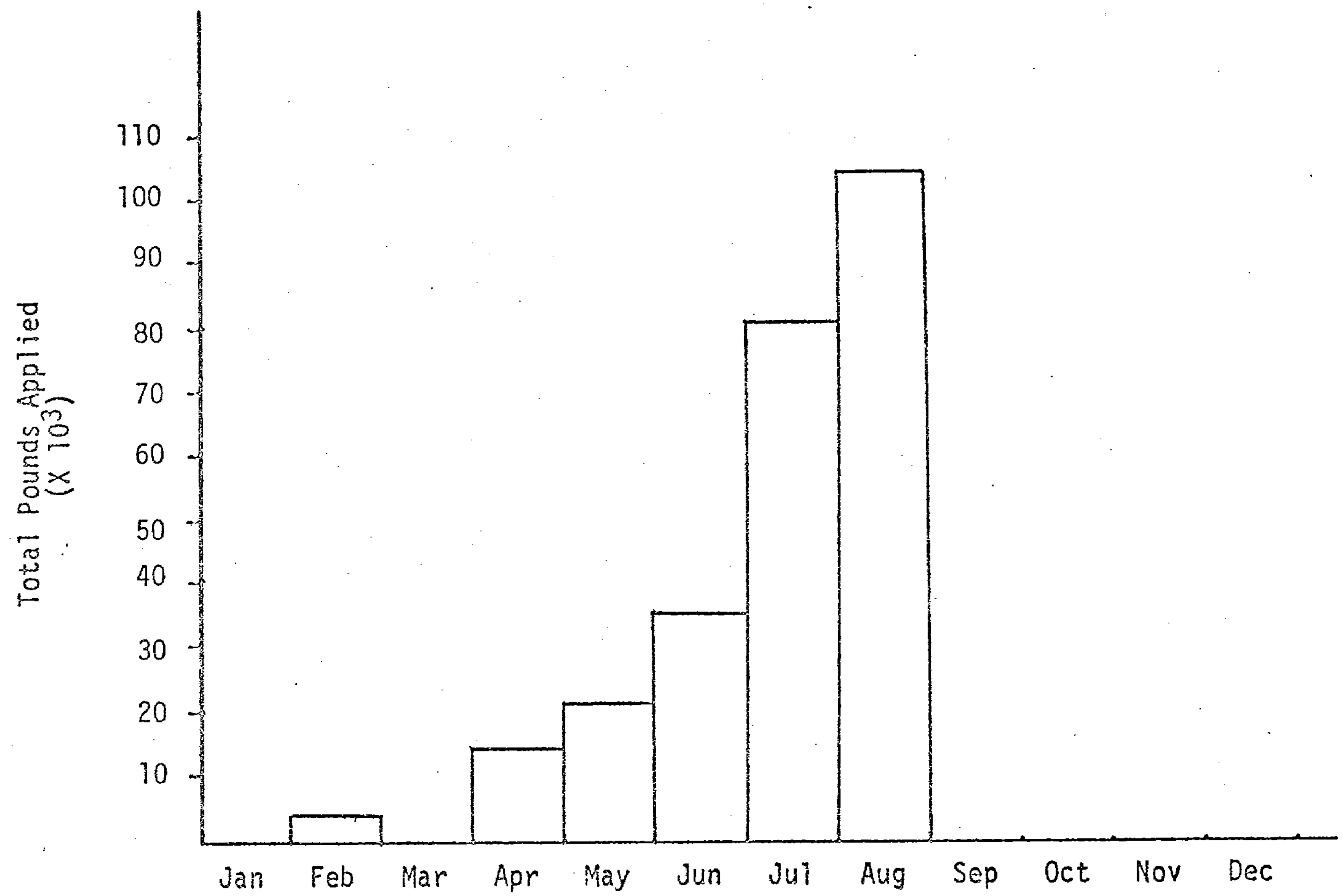

Figure A.5-2. Monthly Distribution of Reported F-10 Oils Used on Celery in 1977 used on direct seeded celery 2 weeks after emergence or on transplants 2 weeks after setting. Other comments under carrots apply.

Chloroxuron is used at a lower rate (2 pounds) postemergence broadcast to direct seeded celery in the 2 leaf stage or celery transplants 2-6 weeks after transplanting. In both cases there is a restriction that stoddard solvent should not be used within 2 weeks before or 3 weeks after chloroxuron application. This almost eliminates the combination of treatments particularly on direct seeded celery.

Both linuron and trifluralin are registered for use but not widely used.

Cultivation is somewhat more important in celery since soil can be thrown into the celery row more readily than it can with carrots and thus provide some weed control.

Although much less oil is used on celery than on carrots it nevertheless serves an important role in early season weed control and should be retained. Growers are already making good use of other herbicides where they can be used. Comments on costs, biocontrol and outlook for new herbicides are the same as discussed under carrots.

Onions

There is limited use of stoddard solvent on onions although it can be used preemergence 2-3 days before the crop emerges or at low rates 30-40 gallons per acre postemergence boradcast up to the "hook" stage when temperatures are below 75° F.

Probably the nearest to a substitute for the oil is the use of sulfuric acid in 30 gallons of water. It is applied postemergence when onions are 6-8 inches high with special spray rigs. Because of the corrosive nature of the acid, great care must be taken in handling and spraying the material. The

Herbicides Used for Weed Control in Celery in California

HERBICIDE	RATE/ACRE ACTIVE INGREDIENT	SPRAY VOLUME WATER/ACRE	TIME OF APPLICATION	WEEDS CONTROLLED	REMARKS
Carrot Oil (STODDARD SOLVENT)	20-40 gal.	Undiluted	2-4 leaf stage	Annual weeds	Use fresh oil only.
Prometryne (CAPAROL®)	1-2 lb.	40-60 gal.	Postemergence 2-6 weeks after transplanting	Annual weeds mainly broad-leaved weeds	Use low rate on light soils and high rate on heavy soils. No more than 2 treatments per crop. Sensitive crops planted after celery may be damaged. See label for specific crops and waiting period.
Nitrofen (TOK®)	4 lb.	40-60 gal.	Preemergence or post-emergence, 1 true leaf stage; or post-transplant, apply 2 weeks after setting crop.	Annual weeds	Use WP for postemergence and transplants; weeds should be very small (1-2 leaf stage) for best weed control. Chickweed, mustard, and common groundsel are resistant at this rate.
Chloroxuron (TENORAN®)	2 lbs.	40-60 gal.	Postemergence broadcast at 2 leaf stage for direct seeded celery or 2-6 weeks after transplant-ing for transplant celery.	Annual weeds	Do not apply petroleum solvents within 2 weeks before or 3 weeks after chloroxuren application.
Linuron (LOROX®)	1.5 lbs.	40-60 gal.	Posttransplant before crop is 8 inches tall	Annual weeds	See label for planting restric-tion for subsequent crops.
Trifluralin (TREFLAN®)	1 lb.	40-60 gal.	Preplant or pretransplant and incorporate into soil.	Annual weeds	See label for planting restric-tion for subsequent crops.

SOURCES: 1972 Crop Weed Control Recommendations, U.C. Div. of Agricultural Science.
Pesticide Use Report by Commodity, 1977, C.D.F.A.
EPA Compendium of Registered Pesticides, Vol. 1, Supplement No. 4, 3/30/77.

usual spray rig for sulfuric acid carries a tank of water and a drum of concentrated acid. The water is pumped through a venturi that picks up and mixes the acid just before it goes into the spray boom. Acid resistant nozzles, boom and fittings are required from the venturi mixing chamber outward. Commercial applicators equipped for acid spraying and knowledgable of the hazzards are usually employed.

Sulfuric acid is not very effective on grassy weeds and some tip burn of the onions may occur at temperatures above 80°F. In spite of these disadvantages, a sizeable number of growers use sulfuric acid as an herbicide.

The most common herbicide used on onions is DCPA (DACTHAL®) as a preemergence application at the time of seeding or transplanting. Rates of 6-10 pounds per acre in 50-75 gallons of water are used with the lower rate on light soils. This herbicide needs incorporation or sprinkler irrigation to carry it into the soil for best results. Several common weed species are tolerant of DCPA, neverthless, it has been widely used. The cost is about $3.00 per pound.

Both chloroxuron at 2 pounds and nitrofen at 4 pounds are also used on onions (see details under carrots) with the caution that chloroxuron should not be used on light sandy soils with less than 1 percent organic matter.

Dinoseb, ammonium salt under several trade names is also used on onions at 3/4-1 1/2 pounds in 20-60 gallons of water per acre postemergence at the 2 leaf stage. It is a foliage contact material weak on grasses and should not be applied at temperatures above 75°F. Care must be used in handling because of its toxicity.

Again, oil use on this crop is relatively minor but important where needed. It is much more effective in controlling grasses than either of the other contact herbicides, sulfuric acid or dinoseb. Possibly sulfuric acid use could be expanded to replace some of the oil but would require more trained and equipped operators to maximize safety and still would not be effective where grasses are a major problem.

The monthly use pattern of reported F-10 oils used on onions during 1977 is shown in Figure A.5-3.

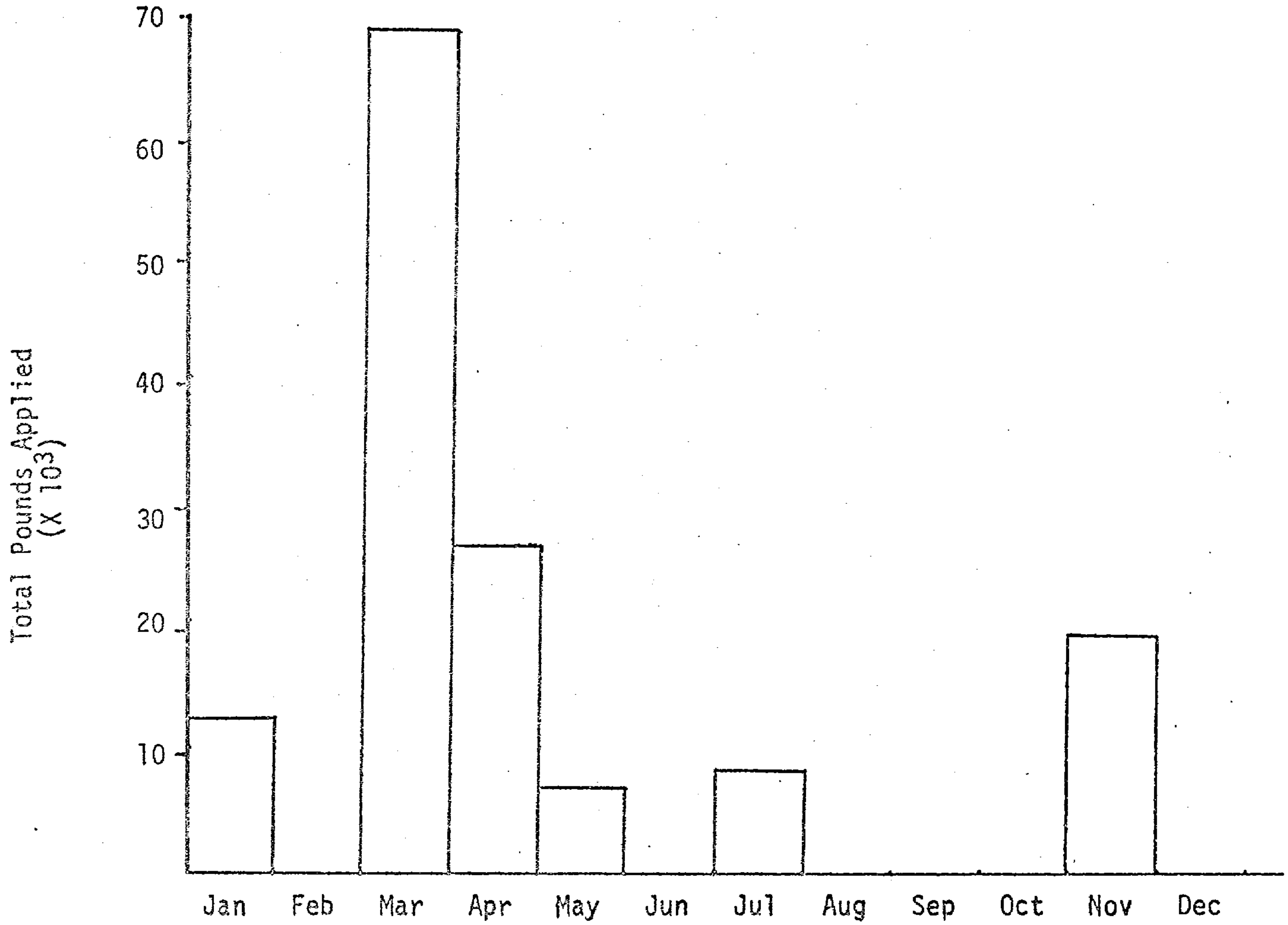

Figure A.5-3. Monthly Distribution of Reported F-10 Oils Used on Onions in 1977

Herbicides Used for Weed Control in Onions in California

HERBICIDE	RATE/ACRE ACTIVE INGREDIENT	SPRAY VOLUME WATER/ACRE	TIME OF APPLICATION	WEEDS CONTROLLED	REMARKS
Carrot Oil (STODDARD SOLVENT)	30-50 gal.	Undiluted	Before crop emerges	Germinating Annuals	Spray just before crop emerges.
Sulfuric Acid	6-8 gal.	80 gal.	Postemergence when onions 6-8 in. high	Annual weeds	Do not spray before onions have 2 true leaves. Use lower rate if air temperature is over 85° F. Tip burn may occur. DANGER: Sulphuric acid is corrasive to most metals and can cause severe burns. Application should be made only by qualified applicators using approved safety equipment.
DCPA (DACTHAL®)	6-10 lb.	50-75 gal.	Preemergence	Annual weeds	Use lower rate on light soils. Injury may occur on soils with high salt content and furrow irrigation. Sprinkler irrigation preferred. When furrow irrigation is used the seedbed should be "well subbed" for best results.
Dinoseb Ammonium Salt (DOW SELECTIVE®) SINOX W®)	3/4-1½ lb.	20-60 gal. ground rig. 10-15 gal. by air	Postemergence 2 leaf stage.	Broadleaved Annual	Do not apply if temperature is above 75°F. Use low rate in inland areas.

Herbicides Used for Weed Control in Onions in California cont.

HERBICIDE	RATE/ACRE ACTIVE INGREDIENT	SPRAY VOL. WATER/ACRE	TIME OF APPLICATION	WEEDS CONTROLLED	REMARK
Chlorpropham (FURLOE®)	8 lb.	20-40 gal.	Preemergence or postemergence to onions in loop stage can repeat in 3-4 leaf stage.	Annual weeds particularly grasses	Do not treat in flag stage or within 1 month of harvest.

SOURCES: 1972 Crop Weed Control Recommendations, U.C. Div. of Agricultural Science
Pesticide Use Report by Commodity, 1977, C.D.F.A.
EPA Compendium of Registered Pesticides, Vol. 1, Supplement No. 4, 3/30/77

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Statement on NSHC pesticide use on deciduous fruit trees prepared by Mr. John Dibble, U.C. Cooperative Extension Entomologist.

Non-synthetic Hydrocarbon Pesticide Use on Deciduous Tree Fruit

1. The use of horticultural spray oils on almonds, peaches, nectarines, apricots, plums, prunes and pears is principally as a dormant or delayed dormant application (Dec.-Feb.). Applied at 6-8 gallons/acre, these oils are combined with an organic phosphate compound (mostly Parathion, Diazinon or Imidan®) mixed with 50-500 gallons of water per acre. When aircraft is used, a total of 10-22 gallons of spray mix is applied. Air applications are not usually by choice but rather because orchards are too wet to enter with ground air carrier sprayers. Approximately 95-98% of all orchards receive this treatment. The principle target pests are Peach twig borer, Anarsia lineatella (Zeller), San Jose Scale, Quadraspidiotus perniciosus (Comstock) and European red mite eggs Panonychus ulmi (Koch). Oil plus the organic phosphate work together (oil aiding in coverage and penetration) in killing peach twig borer and San Jose scale, whereas oil alone coats and sufficates mite eggs. Pear psylla adults are also a target treated with oil alone. Death occurs as a factor of suffocation and gaseous exchange inhibition. The above oil rates relate to the highly refined and narrow range oil. When dormant oil emulsion or dormant emulsive oils are used, 1½-2 times the amount of oil is used. These latter oils are the old spray oils that are used progressively less each season and probably amount to less than 20% of the total oil used in the dormant stage.

2. There are presently no alternative methods of applying oil which could result in reduced applications. Generally, we encourage the use of narrow-range type spray oils since they do not disrupt the orchard

environment. It would appear that we probably cannot reduce the amount of total spray oil used. In fact, we would like to encourage its use through the growing season. Obviously, we can reduce the amount of total gallons of spray oil used per acre if we switch totally from the poorly refined dormant and summer oils that have been used in the past. This is done simply through the use of more efficient higher refined narrow-range types. Also, by switching to low volume or concentrate spraying we can reduce the total amount of any oil per acre by approximately 25%. This technique of application eliminates high gallonage run off and thereby eliminates a certain amount of waste.

3. There are alternative synthetic organic chemical pesticides that can substitute in almost every case where oils are used. However, the efficacy of using an organic by itself in the dormant treatment is generally poor and in our thinking not up to performance standards. Only one product, Supracide®, is recommended as a dormant treatment for peach twig borer and San Jose scale without the addition of oil. Even this product, however, performs better combined with oil. Other than dormant treatments with oil there is presently no product that will control European red mite eggs. As we move into the growing season, oils may be used alone for scale and mite control or again they may be combined with organic phosphates for peach twig borer and scale control. If we substitute a compound in the place of oil for insect and mite control rather than using oil, we probably would not result in increasing the number of applications for total pest control. Even though the grower may not realize as good a control without the addition of oil, we would probably not make an additional application but rather sustain

the 5-10% loss in production quality or yield.

4. In my opinion, there are no alternative control methods to substitute for the present usage of oil such as those you list - biological control, sanitation, cultivation, or burning. Each of these alternatives has a place but generally, they are somewhat limited in practicality.

5 & 6. Integrated pest management has been our aim with each of the deciduous tree fruit crops to emphasize oil usage as much as possible. Even though the use of oils alone for mite control or worm egg suppression may not be as spectacular in control as are some of the synthetic compounds, it is our hope that the lesser degree of control can be worked into a buyer-consumer acceptance. A distinct advantage of oils in regard to mites is that there is no known resistance and the cost of the product. The safety of handling and relatively quick breakdown are all pluses for the encouragement of oil usage. We also find that not only do synthetics perform somewhat better when oil is added to the application (this is probably true because of better spreading, penetration and weathering), but droplet size is also maintained more uniform than non-oil combination sprays. As to oils causing plant damage, we rarely see this problem when used as according to directions. There are definitely some compounds that oil cannot be used in combination with or shortly before or after. These phytotoxic combinations are well defined, appear on the label, and are generally common knowledge. There are some trees or tree conditions, however, which we must warn growers that phytotoxic problems may result with oil use.

For instance, dormant applications on plums and prunes should be delayed until February, and the use during the summer of oils may cause leaf injury on trees suffering for moisture. The latter situation is especially true with almonds.

7. Since it would be difficult to find anybody that would argue with the effectiveness of dormant oil treatment, most likely the only argument for oil substitutes would occur during the growing season. And this specifically would only be in the use of oils in mite control. Such oil sprays are directed at the European red mite, 2-spotted and Pacific mite (the latter two are our most serious summer mites). Where populations are severe, oils are a second best to such miticides as Plictran® and Omite®. Growers in these cases would best be advised to utilize these latter miticides rather than oils. However, if a grower is observant and treats the initial low population of these summer mites with oil, and continues to do so through the season for 2 or 3 applications, oils can be very effective and with such low rates as 1-2 gallons per acre applied in 50-100 gallons total spray. Such oil applications would not necessarily have to be applied by themselves but would most likely go on in combination with a synthetic compound being used for a worm or bug problem. Although this low rate of oil applied 2 or 3 times during the season would mean more applications per season for mites since oil has no residual activity, it would keep the population down to a level that no plant injury would be sustained. In contrast to this program, most growers apply the miticides Plictran® or Omite® only after the population has risen quite high and obviously caused some tree injury.

If either of these above programs are used, we don't expect to have a crop yield effect, especially if the synthetic miticides are used a second time where mite populations return. However, if the cost of the synthetic product is too high, which can be the case for the small, medium sized grower, he generally will not apply a second synthetic application. In this case, the mite population can have an effect on the current season's yield and quality and possibly bud production the following year.